
10. Acceptance Requirements

Acceptance requirements ensure that equipment, controls and systems operate as required by the Standards. The activities specified in these requirements have three aspects:

1. Visual inspection of the equipment and installation
2. Review of the certification requirements
3. Functional tests of the systems and controls

New Acceptance Requirements for 2008

1. Building Envelope Acceptance Test for Fenestration (ENV-2A)
2. Seven new Mechanical Acceptance Test Requirements (MECH-9A through MECH-15A)
3. New Outdoor Lighting Acceptance Test (OTLG-2A)

The envelope acceptance requirements for fenestrations are outlined in §116. Mechanical acceptance requirements are outlined in §125 and the indoor and outdoor lighting acceptance requirements are outlined in §134. The envelope, mechanical and lighting acceptance requirements are detailed in Appendix NA7 of the Reference Nonresidential Appendix.

The acceptance process is a way of assuring that the installation was done in a way that meets the requirements of the Standards. This process assures not only that the appropriate equipment was purchased and installed, but that that equipment is operating properly.

10.2 Overview

Acceptance requirements specify targeted inspection procedures and functional/performance test procedures that serve to determine whether specific building components, equipment, systems, and interfaces between systems conform to the criteria set forth in the Standards, Reference Nonresidential Appendix NA7, and the applicable construction documents (plans and specifications). Acceptance requirements ensure code compliance and promote optimization of system efficiency and performance.

Acceptance testing is not intended to take the place of commissioning or test and balance procedures that a building owner might incorporate into a building project. It is an adjunct process focusing only on demonstrating compliance with the Standards.

Third-party review of the information provided on the Certificate of Acceptance forms is generally not required, but there is one exception: air distribution systems acceptance requirements, for which the duct leakage diagnostic test results must be reported on the Certificate of Acceptance form, are required to be verified by a certified HERS rater as specified in §144(k).

Individual acceptance tests may be performed by one or more *Field Technicians* under the responsible charge of a licensed contractor or design professional, (*Responsible Person*) eligible under Division 3 of the Business and Professions Code, in the applicable classification, to accept responsibility for the scope of work specified by the Certificate of Acceptance document. The *Responsible Person* must review the information on the Certificate of Acceptance form and sign the form to certify compliance with the acceptance requirements. Typically, the individuals who participate in the acceptance testing/verification procedures are contractors, engineers, or commissioning agents. The individuals who perform the field testing/verification work and provide the information required for completion of the acceptance form (*Field Technicians*) are not required to be licensed contractors or licensed design professionals. Only the *Responsible Person* who signs the Certificate of Acceptance form to certify compliance must be licensed.

The acceptance requirements process must address the following:

- Review the bid documents to make sure that sensor locations, devices and control sequences are properly documented,
- Review the installation, and complete the required acceptance testing, and
- Certify the acceptance test results on the Certificate of Acceptance, and submit the certificate to the enforcement agency prior to receiving a final occupancy permit.

This chapter summarizes the requirements for acceptance testing, including the following sections:

- 10.2 – Overview provides an overview of roles, responsibilities and reasons for the acceptance requirements.
- 10.3 – Acceptance Testing Process discusses how acceptance testing fits into plan review, construction inspection, system and functional testing and certification (Certificate of Occupancy).
- 10.4 – Forms include a list of forms necessary for completing the acceptance requirements.
- 10.5 – Mechanical Acceptance Testing Overview addresses requirements for inspecting and testing mechanical systems and controls.
- 10.6 – Lighting Acceptance Testing Overview addresses requirements for inspecting for fenestration label certificate and verifying the installed matches the energy documentation.
- 10.7 – Test Procedures for Envelope and Mechanical Systems.
- 10.8 – Test Procedures for Lighting Equipment.
- 10.9 – Mechanical Forms and Acceptance Requirements details the compliance forms used to document the mechanical acceptance testing.
- 10.10 – Lighting Forms for Acceptance Requirements details the compliance forms used to document the lighting acceptance testing.

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- 10.11 – Outdoor Lighting Forms for Acceptance Requirements addresses requirements for inspecting and testing outdoor lighting systems.

10.2.2 Roles and Responsibilities

To ensure that the acceptance tests are performed, it is critical that the acceptance requirements are incorporated into the construction documents, including information that describes the details of the tests to be performed. This information could be integrated into the specifications for testing and air balance, energy management and control system, equipment startup procedures or commissioning. It is quite possible that the work will be performed by a combination of the Test and Balance (TAB) contractor, mechanical/electrical contractor, and the Energy Management Control System (EMCS) contractor, so applicable roles and responsibilities should be clearly called out to get accurate pricing.

Field Technician

The *Field Technician* is responsible for performing and documenting the results of the acceptance procedures on the Certificate of Acceptance forms. The *Field Technician* must sign the Certificate of Acceptance to certify that the information he provides on the Certificate of Acceptance is true and correct. It is important to note that the *Field Technician* is not required to have a contractor's, architect's or engineer's license. A license is only required of the *Responsible Person* described below.

Responsible Person

A Certificate of Acceptance must be signed by a licensed *Responsible Person* who is eligible under Division 3 of the Business and Professions code in the applicable classification, to take responsibility for the scope of work specified by the Certificate of Acceptance document. The *Responsible Person* can also perform the field testing and verification work, and if this is the case, the *Responsible Person* must complete and sign both the Field Technician's signature block and the *Responsible Person's* signature block on the Certificate of Acceptance form. The *Responsible Person* assumes responsibility for the acceptance testing work performed by his Field Technician agent or employee.

Enforcement Agency

The Certificate of Acceptance must be submitted to the enforcement agency in order to receive the final Certificate of Occupancy. Enforcement agencies shall not release a *final* Certificate of Occupancy unless the submitted Certificate of Acceptance demonstrates that the specified systems and equipment have been shown to be performing in accordance with the applicable acceptance requirements.

The enforcement agency has the authority to require the *Field Technician/Responsible Person* to demonstrate competence, to its satisfaction.

10.2.3 When Are Acceptance Tests Required?

In general the Acceptance Tests apply to new equipment and systems installed in either new construction or retrofit applications. The scope of each test and the specific exceptions to this rule are noted in the following paragraphs. If an acceptance test is required, the appropriate form along with the each specific test must be submitted to the enforcement agency before a final occupancy permit can be granted.

Envelope Test Procedures

ENV-2A: Fenestration Acceptance

- Fenestration product shall have either an NFRC Label Certificate or an Energy Commission's Label Certificate FC-1 or FC-2. Verification of the fenestration product matches energy compliance specifications.

Mechanical Test Procedures

MECH-2A: Ventilation System Acceptance Document

- Variable Air Volume Systems Outdoor Air Acceptance
- New Construction and Retrofit: Applies only to new Variable Air Volume (VAV) systems
- Constant Volume Systems Outdoor Air Acceptance
- New Construction and Retrofit: Applies only to new Constant Air Volume (CAV) systems

MECH-3A: Constant-Volume, Single-Zone, Unitary Air Conditioner and Heat Pump Systems Acceptance Document

- New Construction and Retrofit: Applies only to new constant-volume, single-zone, unitary units with direct expansion (DX) cooling. These units may be cooling only or heating and cooling.

MECH-4A: Air Distribution Systems Acceptance

New Construction (§144K): Only required for single zone units (heating only, cooling only or heating and cooling) serving 5,000 ft² of space or less where 25 percent or more of the duct surface area is in one of the following spaces:

- Outdoors, or
- In a space directly under a roof where the U-factor of the roof is greater than the U-factor of the ceiling, or
- In a space directly under a roof with fixed vents or openings to the outside or unconditioned spaces, or

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- In an unconditioned crawlspace; or
 - In other unconditioned spaces.

Downshot units with ducts in spaces with insulation on the walls and roof need not be sealed. Units with extensive ductwork on the roof or in an uninsulated attic may need to be sealed (it depends on the surface area ratio).

Retrofit (§149): The same scope limitations for zone size, unit type and ductwork location apply as in new construction. With these constraints, requirements for sealing and testing apply to:

- New ductwork serving either new or existing single-zone units (§149(b)1D)
- New ductwork as an extension of existing ductwork with either new or existing single-zone units
- Existing ductwork where the single-zone unit is being replaced or having a major component replaced (§149(b)1E), including:
 - Cooling coil
 - Furnace
 - Condenser coil (split system)
 - Condensing unit (split system)

Different levels of leakage requirements apply to new and existing ductwork (see §149(b)1D).

MECH-5A: Air Economizer Controls Acceptance Document

- *New Construction and Retrofit:* All new equipment with air economizer controls must comply. Units with economizers that are installed at the factory and certified with the Commission do not require functional testing but do require construction inspection.

MECH-6A: Demand-controlled Ventilation Systems Acceptance Document

- *New Construction and Retrofit:* All new DCV controls installed on new or existing HVAC systems must be tested.

MECH-7A: Supply Fan Variable Flow Controls Acceptance Document

- *New Construction and Retrofit:* All new VAV fan volume controls installed on new or existing systems must be tested.

MECH-8A: Valve Leakage Acceptance Document

- *New Construction and Retrofit:* Applies to chilled and hot water systems that are designed for variable flow. It also applies to new boilers and chillers where there is more than one boiler or chiller in the plant and the primary pumps are connected to a common header.

MECH-9A: Supply Water Temperature Reset Controls Acceptance Document

- *New Construction and Retrofit:* Applies to chilled or hot water systems that has a supply temperature reset control strategy programmed into the building automation system.

MECH-10A: Hydronic System Variable Flow Controls Acceptance Document

- *New Construction and Retrofit:* Applies to any water system that has been designed for variable flow, where the pumps are controlled by variable frequency drives (i.e. chilled and hot water systems, water-loop heat pump and air-conditioning systems).

MECH-11A: Automatic Demand Shed Control Acceptance

- *New Construction and Retrofit:* Applies to construction inspection of the EMCS interface shed controls and testing.

MECH-12A: Fault Detection & Diagnostics for DX Units

- *New Construction and Retrofit:* Applies to verifying the FDD hardware matches the manufacturer's cut sheet plans specifications. Fault detection is the primary eligibility criteria for DX units to meet the credit requirements in the performance calculation method.

MECH-13A: Automatic Fault Detection & Diagnostics for Air Handling & Zone Terminal Units

- *New Construction and Retrofit:* Applies to verifying that the air handler and the zone terminal units are functional. Only 5 percent of the terminal boxes (VAV box) shall be tested.

MECH-14A: Distributed Energy Storage DX AC Systems Test

- *New Construction and Retrofit:* Applies to constant and variable volume, direct expansion systems with distributed energy storage (DES/DXAC). This acceptance requirement is an addition to economizer and packaged equipment acceptance.

MECH-15A: Thermal Energy Storage (TES) Systems

- *New Construction and Retrofit:* Applies to thermal energy storage systems that are in conjunction with chilled water air conditioning systems and must meet all eligibility criteria.

Lighting Test Acceptance Procedures

The entire lighting acceptance tests apply to new equipment and controls installed on new or existing lighting systems. These tests include:

LTG-2A: Lighting Control Acceptance Document

- ***New Construction and Retrofit:*** Applies to Occupancy Sensor, Acceptance Manual Daylight Controls Acceptance, and Automatic Time Switch Control Acceptance. Functional testing and verification is required.

LTG-3A: Automatic Daylight Control Acceptance Document

- ***New Construction and Retrofit:*** Applies to properly located controls, field calibrated and set appropriate lighting levels.

Outdoor Lighting Acceptance Test Procedures

OLTG-2A: Lighting Controls

- ***New Construction and Retrofit:*** Applies to functional testing and verification of motion sensor location and ensure the sensor coverage is not blocked by obstruction. Verify the sensor signal sensitivity is adequate. Applies to verification of the outdoor lighting shut-off control and turning off during daytime hours. Verify the astronomical and standard shutoff controls are programmed for weekdays, weekends and holiday schedules.

10.2.4 Why Test for Acceptance?

Building control systems are an integral component of a new building. From simple thermostatic controls and manual light switches to complex building automation systems, controls are an integral part of building health, safety and comfort. They also are a key component of a building's energy efficiency. A Public Interest Energy Research Program (PIER) report titled, Integrated Design of Small Commercial HVAC Systems, Element 4, found the following problems with package rooftop equipment:

- **Economizers.** Economizers show a high rate of failure in the study. Of the units equipped with economizers, 64 percent were not operating correctly. Failure modes included dampers that were stuck or inoperable (38 percent), sensor or control failure (46 percent), or poor operation (16 percent). The average energy impact of inoperable economizers is about 37 percent of the annual cooling energy.
- **Refrigerant charge.** A total of 46 percent of the units tested were improperly charged, resulting in reductions in cooling capacity and/or unit efficiency. The average energy impact of refrigerant charge problems was about 5 percent of the annual cooling energy.
- **Low airflow.** Low airflow was also a common problem. Overall, 39 percent of the units tested had very low airflow rates (< 300 cfm/ton).

The average flowrate of all units tested was 325 cfm/ton, which is about 20 percent less than the flowrates generally used to rate unit efficiency. Reduced airflow results in reduced unit efficiency and cooling capacity. The annual energy impact of low airflow is about 7 percent of the annual cooling energy.

- Cycling fans. System fans were found to be cycling on and off with a call for heating or cooling in 38 percent of the units tested. The supply of continuous fresh air during occupied hours relies on continuous operation of the HVAC unit supply fan.
- Unoccupied fan operation. Fans were also observed to run continuously during unoccupied periods in 30 percent of the systems observed. While this practice improves the ventilation of the space, it represents an opportunity to save energy through thermostat setback and fan cycling during unoccupied periods.
- Simultaneous heating and cooling. Adjacent units controlled by independent thermostats were observed to provide simultaneous heating and cooling to a space in 8 percent of the units monitored in the study. This was largely due to occupant errors in the set up and use of the thermostats, and poor thermostat placement during construction.
- No outdoor air. A physical inspection revealed that about 8 percent of the units were not capable of supplying any outdoor air to the spaces served. In some cases, outdoor air intakes were not provided or were sealed off at the unit. In other instances, outdoor air dampers were stuck shut, preventing outdoor air intake.

Acceptance testing is a way of assuring that targeted building systems were designed, constructed and started up to the intent of the Standards.

10.3 Acceptance Testing Process

The acceptance requirements require four major check-points to be conducted. They are:

- Plan review
- Construction inspection
- Functional testing and verification
- Certificate of Occupancy

These will be discussed in more detail below.

10.3.1 Plan Review

The installing contractor, engineer of record, owner's agent, or the person responsible for certification of the acceptance testing/verification on the Certificate of Acceptance (*Responsible Person*) must review the plans and specifications to ensure that they conform to the acceptance requirements. This is typically done prior to signing a Certificate of Compliance.

In reviewing the plans, the designer will be noting on the ENV-1C, MECH-1C, LTG-1C and the OTLG-1C code compliance forms, all of the respective envelope, mechanical and lighting systems that will require acceptance tests, and the parties responsible for performing the tests. An exhaustive list is required so that that when the acceptance tests are bid, all parties are aware of the scope of acceptance testing on the project.

10.3.2 Construction Inspection

The installing contractor, engineer of record, owner's agent, or the person responsible for certification of the acceptance testing/verification on the Certificate of Acceptance (*Responsible Person*) must perform a construction inspection prior to testing. Reviewing the acceptance requirements with the contractor prior to installation is very useful on several counts.

In some cases, it is most economical to perform testing immediately after installation, which also requires that the installation of any associated systems and equipment necessary for proper system operation is also completed.

Awareness of the acceptance test requirements may result in the contractor identifying a design or construction practice that would not comply with the acceptance requirements prior to installation.

Purchasing sensors and equipment with calibration certificates reduces the amount of time required for site calibration and may keep overall costs down.

The purpose of the construction inspection is to assure that the equipment that is installed is capable of complying with the requirements of the Standards. Construction inspection also assures that the equipment is installed correctly and is calibrated.

10.3.3 Functional Testing

A *Field Technician* must take responsibility for performing the required acceptance requirements procedures. All of the required acceptance tests for a project need not be performed by the same *Field Technician*. However, for each acceptance test performed, the *Field Technician* who performs the test is responsible for identifying all performance deficiencies, ensuring that they are corrected, and if necessary, he must repeat the acceptance requirement procedures until the specified systems and equipment are performing in accordance with the acceptance requirements. The *Field Technician* who performs the testing must sign the Certificate of Acceptance to certify the information he has provided to document the results of the acceptance procedures is true and correct.

A licensed contractor, architect, or engineer (*Responsible Person*), who is eligible under Division 3 of the Business and Professions Code in the applicable classification, to take responsibility for the scope of work specified by the Certificate of Acceptance must review the test results from the acceptance requirement procedures provided by the *Field Technician* and sign the Certificate of Acceptance to certify compliance with the acceptance requirements. Regardless of who performs the tests, a *Responsible Person* must review the forms and sign off on them. The *Responsible Person* may also perform the *Field Technician's* responsibilities, and must then also sign the *Field Technician*

declaration on the Certificate of Acceptance to certify that the information on the form is true and correct.

10.3.4 Certificate of Occupancy

Enforcement agencies shall not release a final Certificate of Occupancy until all required Certificates of Acceptance are submitted. Copies of all completed, signed Certificates of Acceptance are required to be posted, or made available with the building permit(s) issued for the building, and shall be made available to the enforcement agency for all applicable inspections.

10.4 Forms

Acceptance test results are documented using a series of forms. These include a Certificate of Acceptance and individual worksheets to assist in field verification. Table 10-1 shows the acceptance forms and reference Standards sections.

Table 10-1 – Acceptance Forms

Component	Form Name	Standards Reference	Reference Nonresidential Appendix NA7
Envelope	ENV-2A – Fenestration Acceptance	§10-111 & §116	NA7.4.1
Mechanical	MECH-2A – Ventilation Systems - Variable Air and Constant Volume Systems	§10-103(b)4 & §121(b)2 & §125(a)1	NA7.5.1.1 NA7.5.1.2
	MECH-3A – Constant-Volume, Single-Zone, Unitary A/C and Heat Pumps	§121(c)2 & §122 & §125(a)2	NA7.5.2
	MECH-4A – Air Distribution Systems	§125(a)3 & §144(k)	NA7.5.3
	MECH-5A – Air Economizer Controls	§125(a)4 & §144(e)	NA7.5.4
	MECH-6A – Demand Control Ventilation (DVC)	§121(c)4 & §121(c)4E & §125(a)5	NA7.5.5
	MECH-7A – Supply Fan Variable Flow Controls (VFC)	§125(a)6 & §144(c)2C & §144(c)2D	NA7.5.6
	MECH-8A – Valve Leakage Test	§125(a)8 & §125(a)9 & §144(j)1 & §144(j)5 & §144(j)6	NA7.5.7
	MECH-9A – Supply Water Temperature Reset	§125(a)8 & §144(j)4	NA7.5.8
	MECH-10A – Hydronic System Variable Flow Control	§125(a)7 & §144(j) & §144(j)1 & §144(j)5 & §144(j)6	NA7.5.9
	MECH-11A – Automatic Demand Shed Control Acceptance	§122(h) & §125(a)10	NA7.5.10
	MECH-12A – Fault Detection & Diagnostics for DX Units	§125(a)11	NA7.5.11
	MECH-13A – Automatic Fault Detection & Diagnostics for Air Handling & Zone Terminal Units	§125(a)12	NA7.5.12
	MECH-14A – Distributed Energy Storage DX AC Systems Test	§125(a)13	NA7.5.13
	MECH-15A – Thermal Energy Storage (TES) Systems	§125(a)14	NA7.5.14
Indoor Lighting	LTG-2A – Lighting Controls	§119(d) & §119(e) & §131(d)	NA7.6.2, 6.3 and 6.4
Outdoor Lighting	OLTG-2A – Automatic Daylighting Controls and Outdoor Motion Acceptance Test	§119(d),(f) and §132(a and c)	NA7.6.1, NA7.7.1 and 7.7.2

10.5 Envelope & Mechanical Acceptance Testing Overview

10.5.1 Administrative Regulations

§10-103(b)

The administrative requirements contained in the Standards require the envelope and mechanical plans and specifications to contain:

- New for 2008 is Envelope Acceptance Form, ENV-2A, requirements for Fenestration; verify label certificate including thermal performance matches building plans and energy compliance.
- New for 2008 are Mechanical Acceptance Forms, MECH-10A through MECH-15A, additional new mechanical acceptance procedures as indicated below in detail.
- Completed acceptance testing forms for mechanical systems and equipment shown in Table 10-1, record drawings are provided to the building owners within 90 days of receiving a final occupancy permit,
- Operating and maintenance information are provided to the building owner, and
- Installation certificates for mechanical equipment (for example factory installed economizers)

10.5.2 Field Process

The construction inspection is the first step in performing the acceptance tests. In general, this inspection should identify:

- Fenestration product, HVAC Equipment, and controls are properly specified, properly located, identified, correctly installed, calibrated and set points and schedules established.
- Documentation is available to identify settings and programs for each device, and
- For some air distribution systems (as identified in §116(a) and §144(k)), this may include select tests to verify acceptable leakage rates while access is available.

Functional and Verification Testing is to be performed on the following devices:

Envelope

- ENV-1A – Will no longer be used. Required information has been transferred to ENV-2A.
- ENV-2A – Envelope: Fenestration - NFRC or Energy Commissions Label Certificate including site-built fenestration. Label Certificate matches building plans and energy compliance documentation.

Mechanical

- MECH-1A – Will no longer be used. Required information has been transferred to MECH -2A and other Mechanical Acceptance forms.
- MECH-2A – Minimum ventilation controls for all constant and variable air volume systems.
- MECH-3A – Zone temperature and scheduling controls for all constant volume, single-zone, unitary air conditioner and heat pump systems.
- MECH-4A – Duct leakage on a subset of small single-zone systems depending on the ductwork location.
- MECH-5A – Air economizer controls for all economizers that are not factory installed and tested.
- MECH-6A – All demand-controlled ventilation control systems.
- MECH-7A – All supply fan variable flow controls.
- MECH-8A – Valve Leakage for hydronic variable flow systems and isolation valves on chillers and boilers in plants with more than one chiller or boiler being served by the same primary pumps through a common header.
- MECH-9A – Supply water temperature reset control strategies programmed into the building automation system for any water systems (i.e. chilled, hot, or condenser water).
- MECH-10A – Hydronic Variable flow controls on any water system where the pumps are controlled by variable frequency drives (i.e. chilled and hot water systems; water-loop heat pump systems).
- MECH-11A – Automatic Demand Shed Control.
- MECH-12A – Fault Detection & Diagnostic for DX Units.
- MECH-13A – Automatic Fault Detection and Diagnostic Systems (AFDD).
- MECH-14A – Distributed Energy Storage DEC/DX AC systems.
- MECH-15A – Thermal Energy Storage (TES) systems.

10.5.3 Envelope and Mechanical Acceptance Test Issues

Acceptance testing must be tailored for each specific design, job site, and climactic conditions. While the steps for conducting each test and the acceptance criteria remain consistent, the application of the tests to a particular site may vary. The following section discusses some of the known issues that occur when the acceptance tests are applied to a project.

General Issues- Envelope

Important additions to the New Envelope Fenestration Acceptance requirements are:

- Verify thermal performance (U-factor and SHGC) matches energy plans, energy compliance documentation and matches purchase order or receipt.
- If the to be installed fenestration thermal performance is equal or better than the specified or listed on the energy documentation then no further re-compliance is required.
- If the to be installed fenestration is less than the energy documentation then re-compliance is required. Installing less efficient fenestration can increase the building's cooling load and change the overall energy use of the building.
- If using the Performance Approach then the weighted average thermal performance per orientation can be used as long it's equal or better than the specified values as noted above; otherwise, re-compliance is required.

General Issues – Mechanical Combining Tests to Reduce Testing Costs

Many of the acceptance tests overlap in terms of activities. For example, both Reference Nonresidential Appendix NA7.5.1.1 Ventilation systems for Variable Air and Constant Volume Systems Acceptance and NA7.5.6 Supply Fan Variable Flow Controls (FVC) Acceptance require that the zone controls be overridden to force the system into full design flow and low flow conditions. Since the bulk of the time for either test is the process of driving the zone controls (e.g. VAV boxes) into a set position it makes sense to combine these two tests: performing the superset of activities with the boxes at both design and part-load conditions. There are a number of places where combining tests will save time. These are summarized here and described again in the individual test descriptions.

Tests that require override of zone controls:

1. NA7.5.1.1 Ventilation systems for Variable Air Volume Systems Acceptance and NA7.5.6 Supply Fan Variable Flow Controls Acceptance.

Tests that require override of the OSA damper:

1. NA7.5.1.1 Variable Air Volume Systems Outdoor Air Acceptance (or NA7.5.1.2 Constant Volume Systems Outdoor Air Acceptance),
2. NA7.5.4 Air Economizer Controls Acceptance, and
3. NA7.5.5 Demand Controlled Ventilation Systems Acceptance.

Tests that require changing the unit mode of operation:

1. NA7.5.2 Constant Volume, Single-zone, Unitary Air Conditioner and Heat Pumps Systems Acceptance and
2. NA7.5.4 Air Economizer Controls Acceptance.

Tests that require deadheading the circulation pump and overriding control valves:

1. NA7.5.7 Valve Leakage Tests and
2. NA7.5.9 Hydronic System Variable Flow Controls Acceptance.

Internal control delays

Be aware of the potential for delays programmed into many control sequences. The purpose of delays is to prevent the system from controlling too rapidly and becoming unstable. With delays between 5 to 30 minutes, the acceptance testing can be prolonged considerably.

Examples include the normal time that it takes to stroke a damper (typically several minutes end to end) and anti-recycle timers on refrigerant compressors (typically on the order of 5 to 15 minutes).

Initial conditions

Each test instructs the contractor to return the systems to normal operating condition based on the initial schedules, setpoints, and control parameters. These initial settings shall be recorded prior to initiating the testing process.

Obtain correct control sequences before testing

It is essential to know exactly what the control sequences are *before testing begins*. Otherwise, the contractor will not be able to customize the test to the particular systems or verify that the systems work as intended. In many cases, the testing will be performed in conjunction with the controls contractor. Also many of these tests can be performed as part of the equipment/system start-up process.

1. Internal electronic controls are usually documented in the equipment O&M manual.
2. With pneumatic controls, you need to review the control drawings to ascertain how the system is being controlled.
3. With DDC controls, it is best to review the control programming that is currently loaded in the controllers. It is important to note that the actual control logic is often different from the sequences on the design plans and specifications for a number of reasons including:
4. Poorly written or incomplete sequences on the design drawings.
5. Standard practices by the installing EMCS contractor.
6. Issues that arose in the field during control system start-up and commissioning.

Functional Testing based on incorrect sequences will not necessarily yield a valid result.

Estimated Time to Complete

To give the full picture to contractors, the test summaries below ("At-A-Glance") include estimates of the time to complete construction observation as well as functional testing on each system. These estimates are made for a specific test on a specific system and need to be aggregated to estimate the total time for completion on all systems associated with the entire building. These estimates need to be used with caution; times will vary depending on a number of factors including the complexity of the controls, the number of control zones, the number of similar tests and other issues. Expect that the first time a test is performed it will take longer. Subsequent tests will take less time as the tester becomes more experienced and familiar with the test.

10.5.4 Sensor Calibration

A variety of sensors are used to control many facets of heating, ventilating, and air conditioning systems. Confirming that a sensor is measuring the respective parameter accurately is crucial to proper system operation and energy performance. For example, if a supply fan variable frequency drive is controlled based on duct static pressure, then it is imperative that the pressure sensor is measuring accurately. A precise definition of calibration is to perform a set of test procedures under specific conditions in order to establish a relationship between the value indicated by a measuring device and the corresponding values that would be realized by the standard being applied. The most common testing standards have been developed by the National Institute of Standards and Technology (NIST). However, the term “calibration” used in the acceptance tests simply refers to verification that the measured value from a sensor will correspond reasonably well (within 10 percent for pressure or light and within 2°F for temperature) to the actual state of the medium being measured.

The requirement found in a few test procedures for sensor calibration can be met by either having a calibration certificate provided with the sensor from the manufacturer or through field verification. A calibration certificate from the manufacturer verifies that the particular sensor was tested per a traceable standard (typically NIST) and confirmed to be measuring accurately. A factory-calibrated sensor is assumed to be accurate and requires no further testing. Field verification generally requires checking the measured value from the sensor against a calibrated instrument while the sensor is installed in the system. Typically most sensors can be checked at a single operating point if the expected measurement range does not vary significantly. Any adjustments that are necessary to make the field-installed sensor correspond to the value measured by the calibrated instrument can be made at either the transmitter itself or within the control system database.

The following sensors are required to be checked for calibration.

1. Pressure sensors used in variable flow applications (i.e. supply fan or pump variable frequency drive is controlled to maintain a specific pressure setpoint). This is applicable to test procedure(s): NA7.5.6 Supply Fan Variable Flow Controls and NA7.5.9 Hydronic System Variable Flow Controls. Accuracy to 10 percent.
2. Temperature sensors used to control field-installed economizers and supply water temperature reset. This is applicable to test procedure(s): NA7.5.4 Air Economizer Controls Acceptance and NA7.5.8 Supply Water Temperature Reset Controls. Accuracy to 2°F.
3. Carbon dioxide sensors used to implement a demand-controlled ventilation control strategy. This is applicable to test procedure(s): NA7.5.5 Demand-controlled Ventilation Systems Acceptance. Accuracy to 75 PPM (parts per million) of CO₂ concentration.

“System” used to control outdoor air dampers in variable air volume (VAV) systems. There are many different ways to control minimum ventilation in a VAV system, including (but not limited to):

- Supply/return flow tracking
- Direct outdoor air flow measurement

- Constant differential pressure across dedicated ventilation air damper
- Constant mixed air plenum pressure

The term “system” refers to whatever type of control strategy employed to actively control minimum ventilation air flow. This is applicable to test procedure(s): NA7.5.1.1 Variable Air Volume Systems Outdoor Air Acceptance. Overall, the “system” must be able to control flow to within the 10 percent of the design outdoor air ventilation value.

10.5.5 Air and Water Measurements

Balancing. It is recommended that before an occupancy permit is granted for a new building or space, or a new space-conditioning system serving a building or space is operated for normal use, the system should be balanced in accordance with the procedures defined by the Testing Adjusting and Balancing Bureau (TABB) National Standards (2003); the National Environmental Balancing Bureau (NEBB) Procedural Standards (1983); or Associated Air Balance Council (AABC) National Standards (1989).

10.5.6 Factory Air Economizer Certification Procedure

When a manufacturer supplies an HVAC unit with a factory-installed economizer section certified to meet California Energy Commission economizer quality control requirements, the manufacturer shall be responsible for verifying that the unit meets the acceptance requirements and providing a Compliance Certificate.

The manufacturer is also responsible for verifying that the high-limit switch on the economizer is set in compliance with Table 144-C of the Standards.

Equipment components shall be certified as passing the inspections or tests shown in Table 10-2.

Table 10-2 – Certification of Air Economizer Components

Component	Factory Inspect and/or Test
Outdoor Air Temperature or Enthalpy Sensor	Unit mounted outdoor air temperature or enthalpy sensor is calibrated and properly shielded from direct sunlight.
Return Air Temperature or Enthalpy Sensor (if applicable)	Return air temperature or enthalpy sensor supplied with the unit for field-installation is calibrated.
High-Limit Switch	Test and verify high-limit switch showing compliance with Standards Table 144-C per §144(e)3.
Air Economizer Controller	Test and verify that economizer sequences in an integrated fashion per §144(e)2B and can modulate up to 100% outdoor air per §144(e)1A.

In addition to component certification, the economizer system shall be functionally tested as detailed in NA7.5.4.2.

For units with economizers that are factory installed and certified operational by the manufacturer to California Energy Commission economizer quality control requirements, the in-field economizer functional test procedures do not have to be conducted. However, the Construction Inspection section of the Air Economizer

Control acceptance test must be completed. A copy of the manufacturer's Compliance Certificate must be attached to the MECH-5A which provides the following: name; company name; signature and date signed; as well as license number and expiration date

10.6 Lighting Acceptance Testing Overview

Acceptance requirements can effectively improve code compliance and help determine whether lighting equipment meets operational goals and whether it should be adjusted to increase efficiency and effectiveness.

10.6.1 Administrative Regulations

§10-103(b)

The administrative requirements contained in the Standards require the lighting plans and specifications to contain:

1. Completed acceptance testing forms for automatic daylighting controls, manual daylight switching, occupant sensing devices and automatic shut-off controls.
2. Record drawings are provided to the building owners within 90 days of receiving a final occupancy permit.
3. Operating and maintenance information be provided to the building owner.
4. Requirement for the issuance of installation certificates for daylighting controls, occupant sensing devices and automatic shut-off controls.

For example, the plans and specifications would require automatic shut-off lighting controls. A construction inspection would verify the device location and wiring is complete. Acceptance tests would verify proper zoning, on-off functions and overrides to assure the shut-off system is properly functioning. Owners' manuals and maintenance information would be prepared for delivery to the building owner. Finally, record drawing information, including programming information for the automatic shut-off lighting controls must be submitted to the building owner within 90 days of the issuance of a final occupancy permit.

10.6.2 Constructability Plan Review

Although acceptance testing does not require a plan review to be performed by the construction team, the construction team should review the construction drawings and specifications to understand the scope of the acceptance tests and raise critical issues that might affect the success of the acceptance tests prior to starting construction. Any constructability issues associated with the lighting system should be forwarded to the design team so that necessary modifications can be made prior to equipment procurement and installation. As an example, understanding the construction inspection requirements for manual or automatic daylighting controls (NA7.6.3 and NA7.6.1) could prevent expensive rewiring if the circuiting requirements are understood prior to installing the wiring.

Construction Inspection

“Do it right the first time.” It is better to check that the wiring plan complies with the acceptance test requirements before installation. The alternative may result in the wiring not passing the construction acceptance test and rewiring.

Construction inspection should occur while wiring is installed. If changes have to be made to circuiting, it is better to do this while a lift is still on site or before obstructions are installed.

Key circuiting issues are:

1. Wiring for multi-level control. Lamps, luminaires or rows of luminaires are regularly assigned to different circuits so that light levels can be increased uniformly by switching
2. Lighting in the daylight zone has to be on separate circuits from other lighting and, in most cases, must also be wiring for multi-level control.

Construction inspection should also identify:

1. Lighting control devices are properly located, calibrated and setpoints or schedules established,
2. Documentation is available to identify settings and programs for each device.

Testing is to be performed on the following devices:

1. Automatic daylighting controls
2. Manual daylighting controls
3. Occupancy sensing devices, and
4. Automatic shut-off controls

10.6.4 Lighting Acceptance Test Issues

Acceptance testing must be tailored for each specific design, job site, and climatic conditions. While the steps for conducting each test remain consistent, the application of the tests to a particular site may vary. The following section discusses some of the known issues that occur when the acceptance tests are applied to a project.

General Issues

Internal control delays

Be aware of the potential for delays programmed into many control sequences. The purpose of delays is to prevent the system from controlling too rapidly and becoming unstable. With delays between 5 to 30 minutes, the acceptance testing can be prolonged considerably.

Initial conditions

Each test instructs the contractor to return the systems to normal operating condition based on the initial schedules, setpoints, and control parameters. These should be recorded prior to initiating the testing process.

Obtain correct control sequences before testing

It is essential to know exactly how the control sequences are programmed *before testing begins*. Otherwise, the contractor will not be able to customize the test to the particular systems or verify that the systems work as intended. Written control sequences often do not include enough detail to test the system against, or they are found to be incorrect. Testing based on incorrect sequences will not necessarily yield a valid result. In addition, to be successful, the contractor will need to know how to manipulate the control system.

Estimated Time to Complete

To give the full picture to contractors, the At-A-Glance includes the time to complete construction observation as well as functional testing. In addition, the At-A-Glance indicates the time shown is per system (not per building).

10.7 Test Procedures for Envelope & Mechanical Systems

This section includes test and verification procedures for envelope and mechanical systems that require acceptance testing as listed below:

Use the form ENV-2A for documenting

1. Use the forms ENV-2A for documenting NA7.4.1 Fenestration Acceptance verification results.

Use the form MECH-2A for documenting

1. NA7.5.1.1 Variable Air Volume Systems Outdoor Air Acceptance test results
2. NA7.5.1.2 Constant Volume Systems Outdoor Air Acceptance test results

Use the form MECH-3A for documenting

1. NA7.5.2 Constant Volume, Single-zone, Unitary Air Conditioner and Heat Pump Systems test results

Use the form MECH-4A for documenting

- NA7.5.3 Air Distribution Systems test results

Use the form MECH-5A for documenting

- NA7.5.4 Air Economizer Controls test results

Use the form MECH-6A for documenting

- NA7.5.5 Demand Controlled Ventilation (DCV) Systems test results

Use the form MECH-7A for documenting

- NA7.5.6 Supply Fan Variable Flow Controls test results

Use the form MECH-8A for documenting

- NA7.5.7 Valve Leakage Test results

Use the form MECH-9A for documenting

- NA7.5.8 Supply Water Temperature Reset Controls test results

Use the form MECH-10A for

- NA7.5.9 Hydronic System Variable Flow Controls test results

Use the form MECH-11A for documenting

- NA7.5.10 Automatic Demand Shed Control test results

Use the form MECH-12A for documenting

- NA7.5.11 Fault Detection and Diagnostics (FDD) for Packaged Direct-Expansion (DX) Units test results

Use the form MECH-13A for documenting

- NA7.5.12 FDD for Air Handling Units and Zone Terminal Units test results

Use the form MECH-14A for documenting

- NA7.5.13 Distributed Energy Storage DX AC Units test results

Use the form MECH-15A for documenting

- NA7.5.14 Thermal Energy Storage (TES) Units test results

The numbers preceding each test are keyed to the section of the Reference Nonresidential Appendix NA, where the required tests are fully documented.

10.7.5 NA7.5.1.1 Ventilation Systems: Variable Air and Constant Volume Systems

At-A-Glance**NA7.5.1.1 Ventilation Systems: Variable Air Systems****Use Form MECH-2A****Purpose of the Test**

This test ensures that adequate outdoor air ventilation is provided through the variable air volume air handling unit at two representative operating conditions. The test consists of measuring outdoor air values at maximum flow and at or near minimum flow. The test verifies that the minimum volume of outdoor air, as required per §121(b)2, is introduced to the air handling unit when the system is in occupied mode at these two conditions of supply airflow. Note that this test should be performed in conjunction with NA7.5.6 Supply Fan Variable Flow Controls Acceptance test procedures to reduce the overall system testing time as both tests use the same two conditions of airflow for their measurements. Related acceptance tests for these systems include the following:

- NA7.5.4 Air Economizer Controls
- NA7.5.5 Demand-Controlled Ventilation Systems Acceptance (if applicable)
- NA7.5.6 Supply Fan Variable Flow Controls Acceptance

Instrumentation

Performance of this test will require measuring outdoor air flow. The instrumentation needed to perform the task may include, but is not limited to:

- An airflow measurement probe (e.g. hot-wire anemometer or velocity pressure probe), or
- If the system was installed with an airflow monitoring station (AFMS) on the outdoor air, it can be used for the measurements if it has a calibration certificate or is field calibrated.

Test Conditions

To perform the test, it will be necessary to override the normal operation of the controls. The control system of the air handling unit and zone controls must be complete, including:

- Supply fan capacity control (typically a variable speed drive)
- Air Economizer control
- Minimum outdoor air damper control
- Zone airflow control (including zone thermostats and VAV boxes)
- All systems must be installed and ready for system operation, including:
 - Duct work
 - VAV boxes
 - Control sensors (temperature, flow, pressure, etc.)
 - Electrical power to air handling unit and control system components

<ul style="list-style-type: none"> • Completion of air handling unit start-up procedures, per manufacturer's recommendations • Document the initial conditions before executing system overrides or manipulation of the setpoints and schedules. All systems must be returned to normal at the end of the test.
Estimated Time to Complete
<p>Construction inspection: 0.5 hours to 2 hours (depending on complexity and difficulty in calibrating the "system" controlling outdoor air flow)</p> <p>Functional testing: 1 to 3 hours (depending on the type of zone control and the number of zones)</p>
Acceptance Criteria
<p>System controlling outdoor air flow was calibrated in the field or at the factory.</p> <p>Measured outdoor airflow reading is within 10 percent of the total value found on the Standards Mechanical Plan Check document MECH-3C, Column I under the following conditions:</p> <ul style="list-style-type: none"> • Minimum system airflow or 30 percent of total design flow • Design supply airflow
Potential Issues and Cautions
<p>Use caution when performing test during winter months in cold climates. Since outdoor airflow must remain constant as supply fan flow is reduced, total supply flow can approach 100 percent outdoor air. Be sure that all freeze protection and heating coil controls are functioning before performing test.</p> <p>Coordinate test procedures with the controls contractor since they may be needed to assist with manipulation of the BAS to achieve the desired operating conditions.</p> <p>Ensure economizer and demand Controlled ventilation controls are disabled before performing the test.</p>

10.7.6 Test Procedure: NA7.5.1.1 Ventilation Systems: Variable Air Volume Systems,
Use MECH-2A

Construction Inspection

The Acceptance Agent should review the sequences of operation to ensure that the system has been designed for dynamic control of minimum outdoor air and review the installation to make sure that all of the devices that are part of that sequence are indeed installed.

There are a number of means to dynamically control minimum OSA. A survey of common methods is presented in Chapter 4 of the Nonresidential Compliance Manual. After validating that the sequence of control will dynamically control outdoor air check the "System is designed to dynamically control minimum OSA" box in the "Construction Inspection" section of MECH-2A.

There are many ways for the designer to specify an active ventilation air control “system” intended to maintain a constant outdoor air flow rate as supply fan flow rate decreases. For example, a flow station may be installed to measure outdoor air flow rate and modulate the outdoor air dampers accordingly. Or perhaps dampers are modulated to maintain a constant differential pressure across a dedicated outdoor air damper assembly. Regardless of how the outdoor air flow is to be controlled, the sensors, equipment, and control strategy necessary to achieve the desired control must be calibrated as a “system”.

Regardless of the method used, the “system” controlling outdoor air flow must be calibrated either at the factory or in the field. Attach the calibration certificate or field calibration results to the acceptance test form and check the calibration certificate box under the “Construction Inspection” section of MECH-2A.

Functional Testing

Step 1: Disable the air economizer, if applicable. For systems with an air economizer, disabling the economizer will prevent the outdoor air damper from modulating during the test due to atmospheric conditions rather than supply airflow variations. Disabling the economizer is necessary only if the system is in cooling mode and outdoor air temperature is below the economizer high limit setpoint. The economizer can be disabled in a number of ways depending on the control strategy used to modulate the outdoor air dampers:

1. Use the high limit switch by reducing the setpoint (return air value or outdoor air value if a comparative or changeover strategy, respectively, is used) below the current OSA dry-bulb or enthalpy measurement
2. Disable the economizer damper control loop through software if it is a DDC system.

Step 2: Modify VAV boxes to achieve design airflow. The intent is to measure outdoor air flow when the system is operating at or near the design airflow condition. This point is provided along with the minimum operating point to test the minimum OSA control at either end of its control range. There are a number of ways to achieve design airflow including:

1. Override all space temperature cooling setpoints to a low temperature (e.g. 60°F cooling) that will force the VAV boxes into full cooling (may be accomplished by a global command or it may have to be done per individual box).
2. Command all VAV boxes to design flow position (may be accomplished by a global command or it may have to be done per individual box).
3. Set the VAV box minimum flow setpoint to be the same as maximum flow setpoint (may be accomplished by a global command or it may have to be done per individual box).

Verify and Document

Measured outdoor air flow is within 10 percent of design outdoor air flow rate found on Mechanical Plan Check document MECH-3C Column I. Outdoor air flow can be measured directly, or indirectly, in a variety of ways. Acceptable methods for measuring outdoor air flow include, but are not limited to the following techniques:

1. Read the outdoor air flow value measured by an air flow monitoring station if one is installed.
2. Traverse across the outdoor air duct to measure duct velocity, measure duct size, and calculate flow.
3. Measure face velocity at various points across outdoor air intake, measure intake damper size, and calculate flow.
4. Traverse across the supply and return ducts to calculate flow (outdoor airflow can be estimated as the difference between the supply and return airflow rates).

System operation stabilizes within 5 minutes. The intent is to ensure the PID control loops are tuned properly so that the system does not hunt.

Step 3: Drive all VAV boxes to either the minimum airflow or 30 percent of total design airflow. The intent is to measure outdoor air flow when the system is operating at or near a minimum flow condition. This point is provided along with the design point to test the minimum OSA control at either end of its control range. If the system has an airflow monitoring station (AFMS) it will test the accuracy of that AFMS at the lowest velocity, its least accurate point. There are a variety of ways to force the VAV boxes to a minimum position depending on the building automation system capabilities and control strategies used, for example:

1. Override all space temperature setpoints to a wide range (e.g. 60°F heating and 90°F cooling) that will force the VAV boxes into the deadband (may be accomplished by a global command or it may have to be done per individual box).
2. Command all VAV boxes to minimum flow position (may be accomplished by a global command or it may have to be done per individual box).
3. Set maximum flow setpoint to be the same as minimum flow setpoint (may be accomplished by a global command or it may have to be done per individual box).

An alternative method is to manually adjust the VFD until the system airflow is at the desired condition. If the VAV boxes are in control they will open up as you are doing this, so you need to provide some time (about 5 minutes) to allow the system to settle. Be warned that although this is acceptable for testing OSA, this would not meet the requirements of test NA7.5.6 Supply Fan Variable Flow Controls Acceptance for testing the stability of the pressure control loop. These two tests should be done concurrently to minimize cost.

Verify and Document

Measured outdoor air flow is within 10 percent of design outdoor air flow rate found on Mechanical Plan Check document MECH-3-C column I. The methodologies provided earlier for conducting field airflow measurements also apply here.

System operation stabilizes within 5 minutes. The intent is to ensure the PID control loops are tuned properly so that the system does not hunt.

Step 4: Return system back to normal operating condition. Ensure all schedules, setpoints, operating conditions, and control parameters are placed back at their initial conditions. Release any overrides on the economizer or demand ventilation controls.

Exception to Functional Testing Procedures

Air handling systems that have a dedicated fan providing ventilation air to the unit would be exempt from measuring ventilation airflow at minimum and maximum supply airflow conditions. An independent ventilation air fan will deliver a constant minimum outdoor air volume to the air handling unit regardless of the speed of the supply fan. Therefore, the only verification needed for this system type would be to measure the actual CFM delivered by the dedicated ventilation air fan.

Verify and Document

Measured outdoor air flow is within 10 percent of design outdoor air flow rate found on Mechanical Plan Check document MECH-3C column I. The methodologies provided earlier for conducting field airflow measurements also apply here.

10.7.7 NA7.5.1.2 Constant Volume Systems Outdoor Air Acceptance

At-A-Glance

NA7.5.1.2 Constant Volume Systems Outdoor Air Acceptance

Use Form MECH-2A

Purpose of the Test

The purpose of the test is to ensure that adequate outdoor air ventilation is provided through the constant volume air handling unit to the spaces served under all operating conditions. The intent of the test is to verify that the minimum volume of outdoor air, as required per §121(b)2, is introduced to the air handling unit during typical space occupancy. Note that systems requiring demand ventilation controls per §121(c)3 must conform to §121(c)4E regarding the minimum ventilation rate when the system is in occupied mode.

Related acceptance tests for these systems include the following:

- NA7.5.2 Constant-Volume, Single-zone, Unitary Air Conditioners and Heat Pump Systems
- NA7.5.4 Air Economizer Controls (if applicable)
- NA7.5.5 Demand Controlled Ventilation Systems Acceptance (if applicable)

Instrumentation

Performance of this test will require measuring outdoor air flow. The instrumentation needed to perform the task may include, but is not limited to:

- A means to measure airflow (typically either a velocity pressure probe or hot wire anemometer)
- If the system was installed with an airflow monitoring station (AFMS) on the outdoor air it can be used for the measurements if it has a calibration certificate or is field calibrated.

Test Conditions

To perform the test, it may be necessary to override the control system of the air handling unit. The control system of the air handling unit must be complete.

All systems must be installed and ready for system operation, including:

- Air economizer controls
- Duct work
- Control sensors (temperature, flow, thermostats, etc.)
- Electrical power to air handling unit and control system components
- Completion of air handling unit start-up procedures, per manufacturer's recommendations
- Document the initial conditions before overrides or manipulation of the setpoints and schedules. All systems must be returned to normal at the end of the test.

Note: Systems requiring demand ventilation controls per §121(c)3 must conform to §121(c)4E regarding the minimum ventilation rate (refer to NA7.5.5 Demand Controlled Ventilation Systems Acceptance Test).

Estimated Time to Complete

Construction inspection: 0.5 hours

Functional testing: 1 hour (depending on difficulty in measuring outdoor air flow)

Acceptance Criteria

System has a means of maintaining the minimum outdoor air damper position.

Minimum damper position is marked on the outdoor air damper

Measured outdoor air flow is within 10 percent of the total value found on the Standards Mechanical Plan Check document MECH-3C column I.

Potential Issues and Cautions

Do not attempt to set the minimum damper position and perform the acceptance test at the same time. The acceptance test verifies the outdoor airflow of the system after calibration and system set-up is complete. Testing costs can be reduced by conducting the acceptance test immediately after set-up is concluded.

10.7.8 Test Procedure: NA7.5.1.2 Constant Volume Systems Outdoor Air Acceptance,
Use Form MECH-2A

Construction Inspection

System has a means of maintaining a minimum outdoor air damper position:

1. Packaged HVAC systems without an economizer will most likely have a fixed outdoor air damper that can be adjusted manually.
2. Small packaged HVAC systems (< 20 tons) with an economizer will most likely have a controller/actuator that will control the outside and return air dampers (for example, a Honeywell W7459A economizer control package). The economizer control package is responsible for maintaining a minimum ventilation damper position as necessary and will most likely receive operation signals from either a thermostat or through a connection to a central DDC system.
3. Large packaged HVAC systems (> 20 tons) will most likely have either a stand-alone economizer controller/actuator package (for example, a Honeywell W7459A) or a control package similar to a built-up system (i.e. outside and return air dampers controlled by a DDC signal). The stand-alone economizer package may receive operation signals from a thermostat, an internal DDC controller, or a central DDC system. The “built-up” style economizer will most likely be controlled by an internal DDC controller or a central DDC system. Some large package systems may also have a dedicated outdoor air damper/actuator, independent of the economizer control strategy.
4. Built-up HVAC system can control the outside and return dampers through a single actuator and damper linkages or through independent actuators and control signals. The control signals will most likely come from a central DDC system. Some built-up systems may also have a dedicated outdoor air damper/actuator, independent of the economizer control strategy.

Minimum position is marked on the outdoor air damper. The intent is that if the damper position is moved for any reason, it can be returned to the proper position to maintain design minimum outdoor air flow requirements.

Functional Testing

Step 1: Disable the air economizer, if applicable. For systems with an air economizer, disabling the economizer will prevent the outdoor air damper from modulating during the test due to atmospheric conditions rather than supply airflow variations. Disabling the economizer is necessary only if the system is in cooling mode and outdoor air temperature is below the economizer high limit setpoint. The economizer can be disabled in a number of ways depending on the control strategy used to modulate the outdoor air dampers:

1. Use the high-limit switch by reducing the setpoint (return air value or outdoor air value if a comparative or changeover strategy, respectively, is used) below the current OSA dry-bulb or enthalpy measurement

-
2. Disable the economizer damper control loop through software if it is a DDC system.

Verify and Document

Measured outdoor air flow is within 10 percent of design outdoor air flow rate found on Mechanical Plan Check document MECH-3C Column I. Outdoor air flow can be measured directly, or indirectly, in a variety of ways. Acceptable methods for measuring outdoor air flow include, but are not limited to the following techniques:

1. Read the outdoor air flow value measured by an air flow monitoring station if one is installed.
2. Traverse across the outdoor air duct to measure duct velocity, measure duct size, and calculate flow.
3. Measure face velocity at various points across outdoor air intake, measure intake damper size, and calculate flow.
4. Traverse across the supply and return ducts to calculate flow (outdoor airflow can be estimated as the difference between the supply and return airflow rates).

Step 2: Return system back to normal operating condition. Ensure all schedules, setpoints, operating conditions, and control parameters are placed back at their initial conditions. Release any overrides on the economizer or demand ventilation controls.

10.7.9 NA7.5.2 Constant Volume, Single-zone, Unitary Air Conditioner and Heat Pumps Systems Acceptance

NA7.5.2 Constant Volume, Single-zone, Unitary Air Conditioner and Heat Pumps Systems Acceptance

Use Form MECH-3A

Purpose of the Test

The purpose of the test is to verify the individual components of a constant volume, single-zone, unitary air conditioner and heat pump system function correctly, including: thermostat installation and programming, supply fan, heating, cooling, and damper operation. Testing of the economizer, outdoor air ventilation, and demand-controlled ventilation are located in the following sections:

- NA7.5.2 Constant Volume System Outdoor Air Acceptance
- NA7.5.4 Air Economizer Controls Acceptance (if applicable)
- NA7.5.5 Demand Controlled Ventilation Systems Acceptance. (If applicable)

Instrumentation

None required

Test Conditions

Unit and thermostat installation and programming must be complete.

HVAC system must be installed and ready for system operation, including completion of all start-up procedures, per manufacturer's recommendations.

Document the initial conditions before overrides or manipulation of the setpoints and schedules. All systems must be returned to normal at the end of the test.

Estimated Time to Complete

Construction inspection: 0.5 to 1 hour (depending on familiarity with thermostat programming)

Equipment test: 1 to 2 hours

Acceptance Criteria

Thermostat is located within the space-conditioning zone that is served by the respective HVAC system

Thermostat meets the temperature adjustment and dead band requirements of §122(b).

Occupied, unoccupied, and holiday schedules have been programmed per the facility's schedule

Pre-occupancy purge has been programmed to meet the requirements of §121(c)2.

Acceptance Criteria

The following modes of operation function correctly:

- **Occupied heating mode operation:** The supply fan operates continuously, all heating stages operate, cooling is not enabled, and the outdoor air damper is at minimum position.
- **Occupied operation with no heating or cooling load:** The supply fan operates continuously, heating or cooling is not enabled, and the outdoor air damper is at minimum position.
- **Occupied cooling mode operation without economizer:** The supply fan operates continuously, all cooling stages operate, heating is not enabled, and outside damper is at minimum position.
- **Unoccupied operation with no heating or cooling load:** The supply fan shuts off, heating or cooling is not enabled, and the outdoor air damper is closed.
- **Unoccupied operation with heating load:** The supply cycles ON, heating is enabled, cooling is not enabled, and the outdoor air damper is either closed or at minimum position.
- **Unoccupied cooling mode operation without economizer:** The supply cycles ON, cooling is enabled, heating is not enabled, and the outdoor air damper is either closed or at minimum position.
- **Override mode:** System reverts to occupied mode, the supply fan turns ON for duration of override, heating or cooling is enabled as necessary, outdoor air damper opens to minimum position.

Potential Issues and Cautions

Ensure that the supply fan runs continuously in occupied mode and cycles appropriately in unoccupied mode. Cycling refers to the supply fan running only when heating or cooling is

enabled.

When testing the manual override, it may be necessary to adjust the length of the override period to minimize test time. Be sure to reset the override period back to the correct length of time.

Overall test time may be reduced (especially for rooftop HVAC units controlled by thermostats) if two people perform the test - one to manipulate the thermostat while someone else verifies operation at the packaged unit.

The Standards do not mandate the actual differential between occupied and unoccupied setpoints, only that the system must be adjustable down to 55°F for heating and up to 85°F for cooling and that the thermostat can be set for a 5°F deadband.

Setback control is only required for climates where the winter median of extremes is less than or equal to 32°F.

Setup control is only required for climates where the 0.5 percent summer design dry-bulb temperature is greater than or equal to 100°F.

10.7.10 Test Procedure: NA7.5.2 Constant Volume, Single-zone, Unitary Air Conditioner and Heat Pumps Systems Acceptance, Use Form MECH-3A

Test Comments

The following acceptance test procedures are applicable to systems controlled by individual thermostats, internal DDC, or central DDC systems. Most of the tests can be performed through simple manipulation of the individual thermostat or the DDC system controlling each packaged HVAC unit. Specific details and examples of how to perform each test are provided below.

Construction Inspection

Thermostat, or temperature sensor, is located within the zone that the respective HVAC system serves.

Thermostat is wired to the unit correctly. Note that this can be inferred from the acceptance tests.

1. In particular, ensure that multiple stage terminals (i.e., 1st and 2nd stage wires) on the thermostat, both cooling and heating stages, are wired to the corresponding circuits at the unit.
2. Verify that no factory-installed or field-installed jumpers exist across the 1st and 2nd stage cooling terminals at the unit (this will ensure that only the economizer can be enabled as the 1st stage of cooling).
3. For heat pump only, verify the "O" terminal on the thermostat is wired to the reversing valve at the unit.
4. For heat pump only, verify thermostat dip switch or programmable software is set to heat pump.

Thermostat meets the temperature adjustment and dead band requirements of §122(b).

Occupied, unoccupied, and holiday schedules have been programmed per the facility's schedule

Pre-occupancy purge has been programmed to meet the requirements of §121(c)2. This is most easily accomplished by scheduling the unit to start one hour prior to actual occupancy.

Functional Testing

The following procedures are applicable to systems controlled by a programmable thermostat, internal DDC (packaged systems only), or central DDC system.

Step 1: Disable economizer control and demand-controlled ventilation systems (if applicable) to prevent unexpected interactions.

The economizer can be disabled by setting the high-limit setpoint at its maximum value and the demand-controlled ventilation system can be disabled by setting CO₂ setpoint well below current zone CO₂ concentration.

Step 2: Simulate a heating demand during occupied condition. (Mode A on MECH-3A form).

- Either set the "occupied" time schedule to include actual time or adjust time to be within the "occupied" time schedule.
- Set heating setpoint above actual space temperature.

Verify and Document

- Supply fan operates continually during occupied condition.
- Ensure all available heating stages operate. This may require raising the heating setpoint even further so that multiple heating stages can become enabled. For example, many programmable thermostats and DDC control algorithms use time delays and deviation from setpoint to enable multiple heating stages. Setting the heating setpoint very high should prevent the 1st stage of heat from meeting setpoint and allow the system adequate time to enable the 2nd or 3rd stages.
- No cooling is provided by the unit.
- Outdoor air damper is open to minimum ventilation position (*Note:* Outdoor ventilation air requirements will be tested under section NA7.5.1.2 Constant Volume System Outdoor Air Acceptance).

Step 3: Simulate operation in the dead band during occupied condition. (Mode B on MECH-3A form)

- Set "occupied" time schedule to include actual time or adjust time to be within the "occupied" time schedule (whichever is easier).
- Adjust heating and cooling setpoints so that actual space temperature is between the two values.

Verify and Document

- Supply fan operates continually during occupied condition.
- Neither heating nor cooling is provided by the unit.
- Outdoor air damper is open to minimum ventilation position.

Step 4: Simulate a cooling demand during occupied condition. (Mode C on MECH-3A form)

- Set “occupied” time schedule to include actual time or adjust time to be within the “occupied” time schedule (whichever is easier).
- Set cooling setpoint below actual space temperature.

Verify and Document

- Supply fan operates continually during occupied condition.
- Ensure all available cooling stages operate. This may require lowering the cooling setpoint even further so that multiple cooling stages can become enabled. For example, many programmable thermostats and DDC control algorithms use time delays and deviation from setpoint to enable multiple cooling stages. Setting the cooling setpoint very low should prevent the 1st stage of cooling from meeting setpoint and allow the system adequate time to enable the 2nd stage.
- No heating is provided by the unit.
- Outdoor air damper is open to minimum ventilation position.

Step 5: Simulate operation in the dead band during unoccupied condition. (Mode D on MECH-3A form)

- Set “unoccupied” time schedule to include actual time or adjust time to be within the “unoccupied” time schedule (whichever is easier).
- Ensure actual space temperature is in between unoccupied heating and cooling setpoints. Adjust each setpoint as necessary to achieve desired control.

Verify and Document

- Supply fan shuts OFF during unoccupied condition.
- Neither heating nor cooling is provided by the unit.
- Outdoor air damper is fully closed.

Step 6: Simulate heating demand during unoccupied condition. (Mode E on MECH-3A form)

- Set “unoccupied” time schedule to include actual time or adjust time to be within the “unoccupied” time schedule (whichever is easier).
- Set heating setpoint above actual space temperature.

Verify and Document

- Supply fan cycles on with call for heating.
- Heating is provided by the unit.
- No cooling is provided by the unit.
- Outdoor air damper is either fully closed or at minimum position

Step 7: Simulate cooling demand during unoccupied condition. (Mode F on MECH-3A form)

- Set “unoccupied” time schedule to include actual time or adjust time to be within the “unoccupied” time schedule (whichever is easier).
- Set cooling setpoint above actual space temperature.

Verify and Document

- Supply fan cycles on with call for cooling.
- No heating is provided by the unit.
- Cooling is provided by the unit.
- Outdoor air damper is either fully closed or at minimum position.

Step 8: Simulate manual override during unoccupied condition. (Mode G on MECH-3A form)

- Set “unoccupied” time schedule to include actual time or adjust time to be within the “unoccupied” time schedule (whichever is easier).
- Engage the manual override. This could entail pushing an override button, triggering an occupancy sensor, or enabling some other form of override control.

Verify and Document

System reverts back to an “occupied” condition. For a DDC control system, verify the “active” heating and cooling setpoints correspond to those programmed for the occupied condition. For a programmable thermostat, the thermostat may display that it is in the “occupied” mode.

System reverts back to an “unoccupied” condition when manual override time period expires. It may be necessary to adjust the length of the override period to minimize test time.

Step 9: Return system back to normal operating condition.

Ensure all schedules, setpoints, operating conditions, overrides, and control parameters are placed back at their initial conditions.

At-A-Glance**NA7.5.3 Air Distribution Systems Acceptance****Use Form MECH-4A****Purpose of the Test**

The purpose of this test is to verify all duct work associated with all non-exempt constant volume, single-zone, HVAC units (i.e. air conditioners, heat pumps, and furnaces) meet the material, installation, and insulation R-values per §124(a) and leakage requirements outlined in §144(k) for new duct systems or §149(b)1D for existing duct systems.

As detailed in the Standards, this test is only required for single-zone units serving less than 5,000 ft² of floor area where 25 percent or more of the duct surface area is in one of the following spaces:

- Outdoors, or
- In a space directly under a roof where the U-factor of the roof is greater than the U-factor of the ceiling, or
- In a space directly under a roof with fixed vents or openings to the outside or unconditioned spaces, or
- In an unconditioned crawlspace; or
- In other unconditioned spaces.

Within this criteria, this test applies to both new duct systems and to existing duct systems which are either being extended per §149(b)1D or the space conditioning system is altered by the installation or replacement of space conditioning equipment per §149(b)1E, including: replacement of the air handler; outdoor condensing unit of a split system air conditioner or heat pump; cooling or heating coil; or the furnace heat exchanger. Existing duct systems do not have to be tested if they are insulated or sealed with asbestos.

Instrumentation

Performance of this test will require measuring duct leakage. Equipment used:

Fan flowmeter (a fan with a calibrated orifice used to pressurize the ducts) accuracy within 3 percent of measured flow. Contact CalCerts, CBPCA, or CHEERS for proper equipment.

Digital manometer (pressure meter) accuracy within 0.2 Pascals.

Duct leakage tests must be verified by a third party HERS rater who has been certified by a HERS provider that has been approved by the California Energy Commission. There are currently three companies that certify HERS raters. They can be found at <http://www.CalCerts.com>, <http://www.CBPCA.org/> or <http://www.CHEERS.org>.

Test Conditions

For new construction all ductwork must be accessible for visual inspection. Hence, visual inspection must be performed before the ceiling is installed.

All ductwork and grilles should be in place before performing the fan flow test to ensure system depicts normal operating configuration. Hence, testing must occur after visual inspection and installation of the diffusers.

HVAC system must be installed and ready for system operation, including completion of all start-up procedures, per manufacturer's recommendations.

Estimated Time to Complete

Construction Inspection: 0.5 to 2 hours (depending on duct access for visual inspections and availability of construction material documentation (i.e. cut sheets, etc.)

Equipment Test: 3 to 6 hours (depending on how long it takes to seal all supply diffusers and return grills.

Acceptance Criteria

Flexible ducts are not compressed or constricted in any way.

Duct connections meet the requirements of §124 (new ducts only).

Joints and seams are properly sealed according to requirements of §124 (new ducts only).

Duct R-values meet the minimum requirements of §124(a) (new ducts only).

Insulation is protected from damage and suitable for outdoor usage per §124(f) (new ducts only).

The leakage fraction for new HVAC ducts does not exceed 6 percent per §144(k), where the leakage fraction is calculated by dividing total measured leakage flow rate by the total fan system flow rate.

The leakage fraction for existing HVAC ducts does not exceed either 15 percent or overall system leakage is reduced by a 60 percent per §149(b)1D. The leakage fraction is calculated by either dividing total measured leakage flow rate by the total fan system flow rate *OR* by comparing “pre-modification” and “post-modification” measured system leakage values.

Obtain HERS Rater field verification as described in Reference Nonresidential Appendix NA1.

Potential Issues and Cautions

If this test is to be applied to existing duct systems that are having alterations made to the ducts or the HVAC equipment attached to the ducts, test the system leakage before making the alterations.

Ensure all of the supply and return diffusers/grills are sealed tightly, all access panels are in place, and duct ends are sealed tightly prior to leakage testing.

After the test, remember to remove all blockages from the supply and return ducts (i.e., where the supply and return ducts at the HVAC unit were blanked off). Seal any holes drilled in the supply and return ducts for the static pressure probes.

Since a certified California HERS rater must also verify duct leakage performance, it may be prudent to coordinate this test with the HERS rater so that the HERS rater can witness/verify the test simultaneously.

Scope of the Requirements

This test only applies to single-zone units serving less than 5,000 ft² of floor area where 25 percent or more of the duct surface area is in one of the following spaces:

- Outdoors, or
- In a space directly under a roof where the U-factor of the roof is greater than the U-factor of the ceiling, or
- In a space directly under a roof with fixed vents or openings to the outside or unconditioned spaces, or
- In an unconditioned crawlspace; or
- In other unconditioned spaces

Within this criteria, this test applies to both new duct systems and to existing duct systems which are either being extended per §149(b)1D or the space conditioning system is altered by the installation or replacement of space conditioning equipment per §149(b)1E, including: replacement of the air handler; outdoor condensing unit of a split system air conditioner or heat pump; cooling or heating coil; or the furnace heat exchanger. Existing duct systems do not have to be tested if they are insulated or sealed with asbestos.

Purpose (Intent) of Test

The duct work of these small single-zone systems with ducts in unconditioned spaces must meet the duct leakage requirements of §144(k) for new ducts or §149(b)1D for existing ducts. However only new duct systems or the extension of existing ducts must meet the requirements of §124, including construction materials, installation, and insulation R-values. Existing ducts are not required to be brought up to current Standards in terms of insulation, or requirements for joint seams and fasteners.

Construction Inspection

The first component of the construction inspection is to assure that the duct system falls under the scope this test (see above *Scope of the Requirements*). The rest of the construction inspections apply to new duct systems or extensions of existing ducts only.

Perform a brief review of the drawings and construction to verify that the following items are specified in the construction set and installed in the field. A comprehensive review of each duct is not required.

- Drawbands are either stainless steel worm-drive hose clamps or UV-resistant nylon duct ties. Verify compliance by reviewing material cut sheets and visual inspection.

- Flexible ducts are not constricted in any way. For example, ensure the flex duct is not compressed against immovable objects, squeezed through openings, or contorted into extreme configurations (i.e., 180° angles). Flex duct that is constricted can increase system static pressure as well as compromise insulation values. Verify compliance through visual inspection.
- Duct inspection and leakage tests shall be performed before access to ductwork and associated connections are blocked by permanently installed construction material. The intent here is to ensure construction modifications can be made, if necessary, before access to the ductwork is restricted.
- Joints and seams are not sealed with a cloth-back rubber adhesive tape unless used in combination with mastic and drawbands. Verify compliance through visual inspection.
- Duct R-values are verified. Duct insulation R-value shall comply with §124(a), §124(c), and §124(d), and can be verified by reviewing material cut sheets and through visual inspection.
- Insulation is protected from damage, or suitable for outdoor usage, per §124(f). Verify compliance by reviewing material cut sheets and through visual inspection.

Functional Testing

Refer to the *Scope of the Requirements* section above to determine when this test is required. When required, the test will often be conducted by the installer and verified by a HERS rater using the procedures outlined in Reference Nonresidential Appendix NA2., and documented on compliance form, MECH-4A.

The primary metric calculated is the leakage fraction of **total fan flow**. Total fan flow is based on the cooling capacity of heating and cooling equipment and based on the heating capacity of heating only equipment. As described in Reference Nonresidential Appendix NA2.3.6, total fan flow is determined to be 400 cfm/ton for cooling or heating/cooling equipment where a ton of cooling capacity is equal to 12 kBtu/h of cooling capacity. For heating only equipment, total fan flow is 21.7 cfm per kBtu/h rated output capacity. The cooling and heating capacity of equipment can be found on the product nameplate.

For new duct systems, the installer blocks off all of the supply and return registers or diffusers and pressurize the ducts with a fan flowmeter to 25 Pascals (Pa) and records the leakage airflow measured by the fan flowmeter. This leakage amount at 25 Pa is divided by the total fan flow to generate the leakage percentage value. If this leakage percentage is less than or equal to 6 percent, the system passes. If the system does not pass, then the installer should look locate and seal any leaks/gaps until the system conforms to the maximum 6 percent leakage requirement. It is easier to find leaks with the ducts pressurized as one can often feel the air escaping from larger leaks/gaps.

For existing duct systems that are having additional ducts added or are having major repairs or replacement of equipment connected to the ducts, the leakage rate of the existing duct system should be tested first before any alterations proceed. This leakage amount is the **Pre-test** leakage value. After the additional

If after all accessible leaks are sealed, the leakage percentage is still above 15 percent, the installer has two options:

1. If the final test leakage is 60 percent lower than the pre-test leakage rate and a visual inspection finds no accessible leaks, crushed ducts, animal infestation, rusted ducts etc., this will be sufficient to pass this requirement.
2. If the system meets neither the 15 percent leakage percentage nor was it possible to reduce the pre-tested leakage value by 60 percent, then the system must pass a visual inspection by a HERS rater. Unlike the other methods of compliance this method cannot be sampled – every system must be inspected by the HERS rater.

After completing the air distribution system acceptance test, the installer shall affix a sticker to the air handler access door describing if the system met the prescriptive leakage requirements (6 percent leakage for new systems and 15 percent for existing systems) or if the system failed to meet this standard but that all accessible leaks were sealed. The installer supplies the stickers and can have their company logo on them. However, the preceding information must be on the sticker in 14 pt font or larger.

Document management

After conducting the air distribution system acceptance test, the installer or the permit applicant must arrange to have a HERS rater perform the required third party verification. Copies of the *Construction Inspection* and the *Air Distribution System Leakage Diagnostic* sections of the MECH-4A should be sent to the HERS Provider, HERS rater; the Builder (General Contractor or Construction Manager), the Building Owner at Occupancy and a copy must be posted at the construction site and made available for all applicable inspections by the enforcement agency.

The HERS rater must perform field verification and diagnostic testing, document the results on a Certificate of Field Verification and Diagnostic Testing, and send copies of the Certificate of Field Verification and Diagnostic Testing to the Builder (General Contractor or Construction Manager), the Building Owner at Occupancy, and a copy must be posted at the construction site and made available for all applicable inspections by the enforcement agency. If the test complies by virtue of the tested leakage (6 percent for new ducts and 15 percent for existing duct) or by virtue of a 60 percent leakage reduction after the system was repaired or altered, the building permit applicant may choose for the HERS field verification to be completed for the permitted space conditioning unit alone, or alternatively as part of a designated sample group of up to seven space conditioning units for which

the same installing company has completed work that requires field verification and diagnostic testing for compliance. If the sampling method is chosen, the HERS rater must randomly select one system from the group for verification. For existing duct systems that fail both the 15 percent leakage rate and the 60 percent reduction in leakage, the HERS rater must validate all of these systems (100 percent sampling) by visual inspection. Refer to Nonresidential Appendix NA1.5 for additional information about sampling.

Reference material from Reference Nonresidential Appendix NA2.

Below are excerpts of air distribution system acceptance testing requirements from Reference Nonresidential Appendix NA2.1 Air Distribution Diagnostic Measurement and Field Verification.

NA2.2 Instrumentation Specifications

The instrumentation for the air distribution diagnostic measurements shall conform to the following specifications:

NA2.2.1 Pressure Measurements

All pressure measurements shall be measured with measurement systems (i.e. sensor plus data acquisition system) having an accuracy of ± 0.2 Pa. All pressure measurements within the duct system shall be made with static pressure probes, Dwyer A303 or equivalent.

NA2.2.2 Duct Leakage Measurements

Duct leakage air flows during duct leakage testing shall be measured with digital gauges that have an accuracy of ± 3 percent or better.

All instrumentation used for duct leakage diagnostic measurements shall be calibrated according to the manufacturer's calibration procedure to conform to the accuracy requirement specified NA2.2. All testers performing diagnostic tests shall obtain evidence from the manufacturer that the equipment meets the accuracy specifications. The evidence shall include equipment model, serial number, the name and signature of the person of the test laboratory verifying the accuracy, and the instrument accuracy. All diagnostic testing equipment is subject to re-calibration when the period of the manufacturer's guaranteed accuracy expires.

NA2.2.3 Duct Pressurization Apparatus

The apparatus for fan pressurization duct leakage measurements shall consist of a duct pressurization and flow measurement device meeting the specifications in NA2.2.

NA2.3.6 Total Fan Flow

The total fan flow for an air conditioner or a heat pump for all climate zones shall be equal to 400 cfm/rated ton with rated tons defined by unit scheduled capacity at the conditions the unit's ARI rating standard from §112. Airflow through heating only furnaces shall be based on 21.7 cfm/kBtuh rated output

NA2.3.8 Diagnostic Duct Leakage

Diagnostic duct leakage measurement is used by installers and raters to verify that total leakage meets the criteria for any sealed duct system specified in the compliance documents. Table 10-3 shows the leakage criteria and test procedures that may be used to demonstrate compliance.

Table 10-3 – Duct Leakage Tests

Case	User and Application	Leakage criteria, % of total fan flow	Procedure
Sealed and tested new duct systems	Installer Testing HERS Rater Testing	6%	NA2.3.8.1
Sealed and tested altered existing duct systems	Installer Testing HERS Rater Testing	15% Total Duct Leakage	NA2.3.8.1
	Installer Testing and Inspection HERS Rater Testing and Verification	60% Reduction in Leakage and Visual Inspection	NA2.3.8.2 NA2.3.8.4
	Installer Testing and Inspection HERS Rater Testing and Verification	Fails Leakage Test but All Accessible Ducts are Sealed And Visual Inspection	NA2.3.8.3 NA2.3.8.4

NA2.3.8.1 Total Duct Leakage Test from Fan Pressurization of Ducts

The objective of this procedure is for an installer to determine or a rater to verify the total leakage of a new or altered duct system. The total duct leakage shall be determined by pressurizing the entire duct system to +25 Pa with respect to outside with all ceiling diffusers/grilles and HVAC equipment installed. When existing ducts are to be altered, this test shall be performed prior to and after duct sealing. The following procedure shall be used for the fan pressurization tests:

- Verify that the air handler, supply and return plenums and all the connectors, transition pieces, duct boots and registers are installed. The entire system shall be included in the test.
- For newly installed or altered ducts, verify that cloth backed rubber adhesive duct tape has not been used.
- Seal all the supply and return registers, except for one return register or the system fan access. Verify that all outdoor air dampers and /or economizers are sealed prior to pressurizing the system.
- Attach the fan flowmeter device to the duct system at the unsealed register or access door.
- Install a static pressure probe at a supply.

- Adjust the fan flowmeter to produce a + 25 Pa (0.1 in water) pressure at the supply plenum with respect to the outside or with respect to the building space with the entry door open to the outside.
- Record the flow through the flowmeter ($Q_{\text{total},25}$) - this is the total duct leakage flow at 25 Pa.
- Divide the leakage flow by the total fan flow determined by the procedure in Section 3.1.4.2 and convert to a percentage. If the leakage flow percentage is less than the criteria from Table 10-3 the system passes.
- Duct systems that have passed this total leakage test will be sampled by a HERS rater to show compliance.

NA2.3.8.2 Leakage Reduction from Fan Pressurization of Ducts

For altered existing duct systems that have a higher leakage percentage than the Total Duct leakage criteria in NA2.3.8.1, the objective of this test is to show that the original leakage is reduced through duct sealing as specified in NA2.2. The following procedure shall be used:

- Use the procedure in NA2.3.8.1 to measure the leakage before commencing duct sealing.
- After sealing is complete use the same procedure to measure the leakage after duct sealing.
- Subtract the sealed leakage from the original leakage and divide the remainder by the original leakage. If the leakage reduction is 60 percent or greater of the original leakage, the system passes.
- Complete the Visual Inspection specified in NA2.3.8.4.

Duct systems that have passed this leakage reduction test and the visual inspection test must then be verified by a HERS rater to demonstrate compliance.

NA2.3.8.3 Sealing of All Accessible Leaks

For altered existing duct systems that do not pass the Total Leakage test NA2.3.8.1, or Leakage Improvement (NA2.3.8.2) tests, the objective of this test is to show that all accessible leaks are sealed. The following procedure shall be used:

- At a minimum, complete the procedure in NA2.3.8.1 to measure the leakage before commencing duct sealing.
- Seal all accessible ducts.
- After sealing is complete use the same procedure to measure the leakage after duct sealing.
- Complete the Visual Inspection as specified in NA2.3.8.4.

All duct systems that could not pass either the total leakage test or the leakage reduction test must be verified by a HERS rater to demonstrate compliance. This is a sampling rate of 100 percent.

NA2.3.8.4 Visual Inspection of Accessible Duct Sealing

For altered existing duct systems that fail to be sealed to 15 percent of total fan flow, the objective of this inspection is to confirm that all accessible leaks have been sealed. The following procedure shall be used:

1. Visually inspect to verify that the following locations have been sealed:
 - a. Connections to plenums and other connections to the forced air unit.
 - b. Refrigerant line and other penetrations into the forced air unit.
 - c. Air handler door panel (do not use permanent sealing material, metal tape is acceptable).
 - d. Register boots sealed to surrounding material.
 - e. Connections between lengths of duct, as well as connections to takeoffs, wyes, tees, and splitter boxes.
2. Visually inspect to verify that portions of the duct system that are excessively damaged have been replaced. Ducts that are considered to be excessively damaged are:
 - a. Flex ducts with the vapor barrier split or cracked with a total linear split or crack length greater than 12 inches.
 - b. Crushed ducts where cross-sectional area is reduced by 30 percent or more.
 - c. Metal ducts with rust or corrosion resulting in leaks greater than 2 inches in any dimension.
 - d. Ducts that have been subject to animal infestation resulting in leaks greater than 2 inches in any dimension.

NA2.3.8.5 Labeling requirements for tested systems

A sticker shall be affixed to the exterior surface of the air handler access door with the following text in 14 point font describing the following:

California Air Distribution Acceptance (Duct Leakage) Certification

"The leakage of the air distribution ducts was found to be ____CFM @ 25 Pascals or ____% of total fan flow.

This system (check one):

- ☐ Has a leakage rate that is **equal to or lower** than the prescriptive requirement of 6% leakage for new duct systems or 15% leakage for alterations to existing systems. It meets the prescriptive requirements of California Building Energy Efficiency Standards.
- ☐ Has a leakage rate **higher than** 6% leakage for new duct systems or 15% leakage for altered existing systems. It does NOT meet or exceed the prescriptive requirements of the Standards. However, all accessible ducts were sealed.

Signed: _____

Print name: _____

Print Company Name: _____

Print Contractor License No: _____

Print Contractor Phone No: _____

Do not remove this sticker

10.7.13 NA7.5.4 Air Economizer Controls Acceptance

At-A-Glance

NA7.5.4 Air Economizer Controls Acceptance

Use Form MECH-5A

Purpose of the Test

The purpose of functionally testing an air economizer cycle is to verify that an HVAC system uses outdoor air to satisfy space cooling loads when outdoor air conditions are acceptable. There are two types of economizer controls; Stand-alone packages and DDC controls. The stand-alone packages are commonly associated with small unitary rooftop HVAC equipment and DDC controls are typically associated with built-up or large packaged air handling systems. Test procedures for both economizer control types are provided.

For units with economizers that are factory installed and certified operational by the manufacturer to California Energy Commission economizer quality control requirements, the in-field economizer functional tests do not have to be conducted. A copy of the manufacturer's certificate must be attached to the MECH-5A. However, the Construction Inspection, including compliance with high temperature lockout temperature setpoint, must be completed regardless of whether the economizer is field or factory installed.

Instrumentation

None required

Test Conditions

Equipment installation is complete (including HVAC unit, duct work, sensors, control system, thermostats).

Non-DDC DX systems are required to have a two-stage thermostat.

HVAC system must be ready for system operation, including completion of all start-up procedures per manufacturer's recommendations.

For those units having DDC controls, it may be necessary to use the building automation system (BAS) to override or temporarily modify the variable(s) to achieve the desired control. BAS programming for the economizer, cooling valve control, and related safeties must be complete.

For built-up systems all interlocks and safeties must be operable--for example, freeze protection, limit switches, static pressure cut-out, etc.

Document the initial conditions before overrides or manipulation of the settings. All systems must be returned to normal at the end of the test.

Estimated Time to Complete

Construction Inspection: 0.5 to 1 hours (depending on familiarity with the controls)

Functional testing: 0.5 to 2 hours (depending on familiarity with the controls and issues that arise during testing)

Acceptance Criteria

If the economizer is factory installed and certified, a valid factory certificate is required for acceptance. No additional equipment tests are necessary.

Air Economizer lockout setpoint complies with Standards Table 144-C per §144(e)3. Outside sensor location accurately reads true outdoor air temperature and is not affected by exhaust air or other heat sources.

All sensors are located appropriately to achieve the desired control.

During economizer mode, the outdoor air damper modulates open to a maximum position and return air damper modulates 100 percent closed.

The outdoor air damper is 100 percent open before mechanical cooling is enabled and for units 75,000 Btuh and larger remains at 100 percent open while mechanical cooling is enabled (economizer integration when used for compliance).

When the economizer is disabled, the outdoor air damper closes to a minimum position, the return damper modulates 100 percent open, and mechanical cooling remains enabled.

Potential Issues and Cautions

If conditions are below freezing when test is performed, coil(s) may freeze when operating at 100 percent outdoor air.

Outdoor air and relief dampers should be closed when the system is in unoccupied and warm-up modes, preventing problems with unconditioned air entering the building during unoccupied hours.

If the damper interlocks fail and the outdoor air damper does not open before the return damper closes, damage to the air handling unit or associated duct work may occur.

Air Economizers with poor mixing can have excessively stratified air streams that can cause comfort problems or freeze stat trips. Mixing problems are more likely to occur as the VAV system reduces flow, leading to reduced velocities in the mixing box and through the dampers.

Check for exterior doors standing open and other signs of building over-pressurization when all units are on full economizer cooling (100 percent OSA).

10.7.14 Test Procedure: NA7.5.4 Air Economizer Acceptance, Use Form MECH-5A

Purpose (Intent) of Test

There are basically two types of economizer controls: 1) stand-alone packages (e.g. Honeywell W7459A, Trane Precedent or Voyager, Carrier Durablade, which are most common); and 2) DDC controls. The stand-alone packages are most commonly associated with rooftop packaged HVAC equipment and DDC controls are typically associated with built-up or large packaged air handling systems. Test procedures for both economizer control types have been developed and a brief description of each control strategy is provided below.

If the economizer is factory installed and certified by the manufacturer to the California Energy Commission, no field testing is required.

The typical economizer control will have the following components: a controller (stand alone or DDC); an actuator that will drive both outside and return air dampers (sometimes separate actuators in built-up systems); an outdoor air sensor; a return air sensor where differential high-limit controls are used; and a mixed/discharge air temperature sensor to which the economizer is controlled. The sensor types used to measure outside and return air include dry-bulb temperature sensors, enthalpy sensors, and electronic enthalpy sensors (a combination of dry-bulb and enthalpy).

In general, a first-stage call for cooling from the zone thermostat will enable the economizer controller, which will either allow the outdoor air damper to open fully if outdoor air conditions are suitable or enable the compressor. The four strategies available for economizer control are: 1) fixed dry-bulb; 2) fixed enthalpy; 3) differential dry-bulb; and 4) differential enthalpy. The fixed dry-bulb and enthalpy strategies both compare outdoor air conditions to a “fixed” setpoint to determine if the economizer can be enabled, whereas differential dry-bulb and enthalpy strategies compares outdoor air and return air conditions to enable the economizer when outdoor air conditions are more favorable. When the zone

thermostat calls for a second-stage of cooling, the compressor is enabled to provide mechanical cooling. The economizer is considered integrated if the economizer can operate simultaneously with the compressor or chilled water coil. If the controls disable the economizer when the compressor (or chilled water coil) is on, it is considered non-integrated. Where economizers are required by the Standards, they must have integrated controls.

Construction Inspection

Air Economizer high temperature lockout setpoint complies with Standards Table 144-C per §144(e)3. For DDC control systems, the lockout setpoint should be a control parameter in the sequence of operations that can be verified for compliance. For stand-alone packages, the lockout setpoint is determined by settings on the controller (for example A, B, C, D settings on the Honeywell W7459A controller or dip switches on a Trane control package). Consult with manufacturer's literature to determine the appropriate A, B, C, D or dip switch settings. Note that snap disks may not comply with lockout requirements in some climate zones. A snap disk is a thermostat-type control device with a fixed setpoint. The snap disk will close the economizer circuit when air temperature is below setpoint and open the circuit when the air temperature exceeds setpoint. Snap disks are not adjustable and can disable the economizer anywhere between 65°F and 70°F. Hence, snap disks will fail unless the manufacturer can provide documentation verifying the snap disk operating temperature complies with Standards Table 144-C. The control complies if the high limit lockout setpoint is less than the values specified in the table.

Table 10-4 – Standards Table 144-C Air Economizer High Limit Shut Off Control Requirements

Device Type	Climate Zones	Required High Limit (Economizer Off When):	
		Equation	Description
Fixed Dry Bulb	1, 2, 3, 5, 11, 13, 14, 15 & 16	$T_{OA} > 75^{\circ}\text{F}$	Outdoor air temperature exceeds 75°F
	4, 6, 7, 8, 9, 10 & 12	$T_{OA} > 70^{\circ}\text{F}$	Outdoor air temperature exceeds 70°F
Differential Dry Bulb	All	$T_{OA} > T_{RA}$	Outdoor air temperature exceeds return air temperature
Fixed Enthalpy ^a	4, 6, 7, 8, 9, 10 & 12	$h_{OA} > 28 \text{ Btu/lb}^b$	Outdoor air enthalpy exceeds 28 Btu/lb of dry air ^b
Electronic Enthalpy	All	$(T_{OA}, RH_{OA}) > A$	Outdoor air temperature/RH exceeds the "A" set-point curve ^c
Differential Enthalpy	All	$h_{OA} > h_{RA}$	Outdoor air enthalpy exceeds return air enthalpy
<i>a. Fixed Enthalpy Controls are prohibited in climate zones 1, 2, 3, 5, 11, 13, 14, 15 & 16.</i>			
<i>b. At altitudes substantially different than sea level, the Fixed Enthalpy limit value shall be set to the enthalpy value at 75°F and 50% relative humidity. As an example, at approximately 6000 foot elevation the fixed enthalpy limit is approximately 30.7 Btu/lb.</i>			
<i>c. Set point "A" corresponds to a curve on the psychrometric chart that goes through a point at approximately 75°F and 40% relative humidity and is nearly parallel to dry bulb lines at low humidity levels and nearly parallel to enthalpy lines at high humidity levels.</i>			

1. For stand-alone packages only, verify that a two-stage thermostat is used, and that the system is wired so that the economizer is the first stage of cooling and the compressor is the second stage. The two-stage space thermostat must have wires connected to Y1 and Y2 on the thermostat landed on the respective Y1 and Y2 terminals at the unit. There should not be any jumpers installed across Y1 and Y2 at the thermostat or the unit. For York units in particular, verify that the “J1” jumper located on the OEM board has been removed. The units come from the factory with the “J1” jumper installed and must be removed in the field (the “J1” jumper is the same as having a jumper across the Y1 and Y2 terminals – the compressor and economizer come on simultaneously on a call for cooling, which effectively makes the economizer inoperable). Note that if a single-stage thermostat is installed, there should not be any jumper between Y1 and Y2.
2. Air Economizer outside (lockout) sensor location is adequate to achieve the desired control. Outdoor air sensors should be located away from building exhausts and other heat sources like air-cooled condensers and cooling towers; should be open to the air but not exposed to direct sunlight (unless it is provided with a radiation shield); and could be located either directly in the air stream or remote from the unit (for example mounted on a north-facing wall).
3. Ensure all systems have some method of relief to prevent over pressurization of the building. Most packaged HVAC units with stand-alone economizer controls will typically have barometric dampers to exhaust the return air when the return dampers are fully closed and the unit is in economizer mode. Built-up and larger packaged air handling units may control return fans, relief dampers, or dedicated relief fans to actively maintain building pressurization when the unit is in economizer mode.

Functional Testing

Since the test procedures vary significantly between stand-alone packages and DDC controls, the procedures for each system type are provided. In addition, there can be significant differences in test procedures between various stand-alone packages themselves. Contact your equipment supplier to see if they have equipment and test protocols that will allow you to easily field test their economizer to NA7.5.4 Air Economizer Acceptance for filling out form MECH-5A. While it would not be feasible to cover every variation, three of the most common stand-alone packages are discussed below. The common feature of these procedures is that they all exercise the economizer function either by enabling an on-board diagnostic function or by “fooling” the control by inserting resistors that simulate mild weather conditions while the system is in cooling mode.

Stand-alone Package

Trane Voyager and Precedent Series. Both of these control packages have internal test sequences that can be used to verify proper system operation. Each operating mode is enabled by providing a momentary (2 second) jump across the test terminals.

Step 1. Use internal test sequences to enable operating modes.

Refer to manufacturer's literature for detailed description of the procedures, however the basic steps are outlined below:

- 1st jumper – supply fan is enabled
- 2nd jumper – economizer mode is enabled
- 3rd jumper – compressor is enabled
- 4th jumper – heating stage is enabled

Verify and Document

- Outdoor air damper is at minimum position when the supply fan is enabled.
- The outdoor air damper opens completely and the return damper closes completely during economizer mode.
- Outdoor air damper is at minimum position when the compressor is enabled.
- Outdoor air damper is at minimum position when heating is enabled.
- Verify the mixed/discharge cut-out sensor wire is landed on the SA terminal on the OEM board. If the sensor wire is not landed on the SA terminal, the economizer will not operate.

Step 2. Return system to normal operation.

Taking the system out of test mode can be accomplished by shutting power off to the unit. The unit will return to normal operation when power is restored.

Verify and Document

- Final economizer changeover dip-switch settings comply with Standards Table 144-C per §144(e)3.

Honeywell controllers. There are many Honeywell controllers available, but the most common is the W7459A series and most of the procedures used to check out this controller can be used on the others as well (always refer to manufacturer's literature for additional information). All Honeywell controllers have an Install a 620 Ohm resistor across the SR and + terminals on the adjustment pot with "A, B, C, D" settings. For a fixed changeover strategy, the position of the adjustment pot with respect to the A, B, C, D settings will determine the economizer lockout setpoint. For a differential changeover strategy, the controller should be on the "D" setting. Note that the controllers typically come from the

factory with the adjustment pot at the “D” setting, but this does not mean a differential control strategy is being used. The easiest way to verify a differential changeover strategy is to look at the S_R and + terminals on the controller. If standard sensor wires are connected to the terminals, then it is a differential control strategy. If there is a 620 Ohm resistor jumpered across these terminals, then a fixed control strategy is being used.

Step 1. Simulate a cooling load and enable the economizer.

The simplest way to determine if the controller is functioning is to:

- Turn the unit OFF at the disconnect.
- Install a 1.2K Ohm resistor across the S_O and + terminals on the controller (this is the outdoor air temperature sensor).
- Install a 620 Ohm resistor across the S_R and + terminals on the controller (this resistor is already installed for a fixed control strategy and must only be installed if there is a return air sensor).
- Turn the economizer setpoint adjustment pot all the way to the “A” setting.
- Install a jumper across the R and Y1 terminals at the unit terminal strip.
- Disconnect the wire from the Y2 terminal at the unit terminal strip (this will prevent the 2nd stage of cooling from being enabled during the test).
- Turn the unit back ON at the disconnect.

Verify and Document

- Outdoor air dampers open fully. Adjust linkages, if necessary, to ensure dampers are at the desired position.
- Return air dampers close completely. Adjust linkages, if necessary, to ensure dampers are at the desired position.
- Compressor does not run.

Step 2. Simulate a cooling load and disable the economizer.

Continuing from above:

- Turn the unit OFF at the disconnect.
- Leave the 1.2K Ohm resistor across the S_O and + terminals and 620 Ohm resistor across the S_R and + terminals in place.
- Turn the economizer setpoint adjustment pot all the way to the “D” setting.
- Leave jumper across the R and Y1 terminals at the unit terminal strip.
- Leave Y2 disconnected.
- Turn the unit back ON at the disconnect.

Verify and Document

- Outdoor air dampers close to minimum position. Adjust linkages, if necessary, to ensure dampers are at the desired position.

-
- Return air dampers open completely. Adjust linkages, if necessary, to ensure dampers are at the desired position.
 - Compressor operates.

Step 3: Return system back to normal operating condition.

- Remove all jumpers and reconnect all wires.

Verify and Document

- Final economizer changeover setting (A, B, C, D) complies with Standards Table 144-C per §144(e)3. Consult with manufacturer's literature to determine the appropriate A, B, C, D setting for both fixed dry-bulb or enthalpy control strategies. The controller must be set on "D" for all differential control strategies.

Carrier Durablade. Most Carrier HVAC units utilize the "Durablade" economizer control package, which uses a single damper "blade" that slides on a worm gear across both the outside and return air streams. Blade position is determined by end-switches that will cut power to the drive-motor when desired damper position is reached. Typically the economizer will be controlled by either a fixed dry-bulb or fixed enthalpy control strategy. Enthalpy control typically utilizes a customized Honeywell controller and the checkout procedures outlined above can be used to determine economizer functionality. The following test procedures should be followed for a fixed dry-bulb strategy.

Step 1 Simulate a cooling load and enable the economizer.

The simplest way to determine if the economizer is functioning is to:

- Turn the unit OFF at the disconnect.
- Install a jumper across the outdoor air temperature thermostat.
- Install a jumper across the R and Y1 terminals at the unit terminal strip.
- Disconnect the wire from the Y2 terminal at the unit terminal strip (this will prevent the 2nd stage of cooling from being enabled during the test).
- Turn the unit back ON at the disconnect.

Verify and Document

- Damper blade slides completely across the return air duct and mixed air plenum is open to the outdoor air intake. Adjust end-switches as necessary to achieve the desired position.
- Compressor does not run.

Step 2 Simulate a cooling load and disable the economizer.

Continuing from above:

- Turn the unit OFF at the disconnect

- Remove the jumper and disconnect the outdoor air sensor completely from the circuit
- Leave Y2 disconnected
- Turn the unit back ON at the disconnect

Verify and Document

- Damper blade returns to minimum outdoor air position. Adjust end switches as necessary to achieve the desired position
- Compressor operates

Step 3: Return system back to normal operating condition.

- Remove all jumpers and reconnect all wires

Verify and Document

- Final economizer changeover setting complies with Standards Table 144-C per §144(e)3

DDC Controls

Step 1. Simulate a cooling load and enable the economizer.

Simulating a cooling load and enabling the economizer can be accomplished by:

1. Commanding the discharge air temperature setpoint to be lower than current discharge conditions.
2. For a fixed dry-bulb or enthalpy control strategy, raising the economizer lockout setpoint to be above current outdoor air conditions (if this is not the case already) to enable the economizer.
3. For a differential dry-bulb or enthalpy control strategy; raising the return air conditions to be above current outdoor air conditions (if this is not the case already) to enable the economizer.

Verify and Document

1. Outdoor air damper modulates open to a maximum position.
2. Return air damper modulates closed and is 100 percent closed when the outdoor air dampers are 100 percent open. Return dampers should close tight to minimize leakage.
3. Outdoor air damper is 100 percent open before mechanical cooling is enabled. This implies that cooling coil valves in chilled water systems should not modulate or compressors in DX systems should not start until the unit is in 100 percent economizer mode. Depending on the speed of the PID loop, it is possible that mechanical cooling could be commanded on before the outdoor air dampers actually stroke fully open. If this occurs, it does not mean the system has failed the test. One option is to watch the output of the PID loop and verify that the *COMMAND* sent to the outdoor air damper reaches 100 percent before a command is sent to the mechanical cooling devices.

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4. Although space pressurization requirements are not part of the current Standards, most systems employ some form of control strategy to maintain space pressure during economizer mode. Control strategies can include, but are not limited to: 1) return fan speed control; 2) dedicated relief fans; or 3) relief damper controls. Observe that the space served by the air handling unit being tested does not appear to experience any pressurization problems (i.e., perimeter doors pushed open or excessive airflow between zones served by different units).

Step 2 Simulate a cooling load and disable the economizer.

Continuing from the procedures outlined in Step 1:

1. Keep the discharge air temperature setpoint lower than current discharge conditions.
2. For a fixed dry-bulb or enthalpy control strategy, lower the economizer lockout setpoint to be below current outdoor air conditions (if this is not the case already) to disable the economizer.
3. For a differential dry-bulb or enthalpy control strategy; lower the return air conditions to be below current outdoor air conditions (if this is not the case already) to disable the economizer.

Verify and Document

1. Outdoor air damper closes to a minimum position.
2. Return air damper opens to normal operating position when the system is not in economizer mode.
3. Mechanical cooling remains enabled to satisfy discharge air temperature setpoint.

Step 3: Return system back to normal operating condition.

1. Ensure all schedules, setpoints, operating conditions, and control parameters are placed back at their initial conditions.

10.7.15 NA7.5.5 Demand-controlled Ventilation Systems Acceptance

At-A-Glance

NA7.5.5 Demand-controlled Ventilation Systems Acceptance Use Form MECH-6A

Purpose of the Test

The purpose of the test is to verify that systems required to employ demand Controlled ventilation (refer to §121(c)3) can vary outside ventilation flow rates based on maintaining interior carbon dioxide (CO₂) concentration setpoints. Demand Controlled ventilation refers to an HVAC system's ability to reduce outdoor air ventilation flow below design values when the space served is at less than design occupancy. CO₂ is a good indicator of occupancy load and is the basis used for modulating ventilation flow rates.

Instrumentation

To perform the test, it may be necessary to vary and possibly measure (if calibration is necessary) ambient CO₂ levels. The instrumentation needed to perform the task may include, but is not limited to:

- Hand-held reference CO₂ probe calibrated to ±10 ppm
- Calibrated gas

Test Conditions

Equipment installation is complete (including HVAC unit, duct work, sensors, and control system).

HVAC system must be ready for system operation, including completion of all start-up procedures per manufacturer's recommendations.

Building automation system (BAS) programming (if applicable) for the air handler and demand Controlled ventilation strategy must be complete. To perform the test, it may be necessary to use BAS to override or temporarily modify the CO₂ sensor reading.

Air Economizer is disabled so that it will not interfere with outdoor air damper operation during test.

Document the initial conditions before overrides or manipulation of the settings. All systems must be returned to normal at the end of the test.

Estimated Time to Complete

Construction inspection: 0.5 to 1 hours (depending on CO₂ sensor calibration)

Functional testing: 1 to 2 hours (depending on how ambient CO₂ concentration levels are manipulated, system response time to variations in CO₂)

Acceptance Criteria

Each CO₂ sensor is factory calibrated (with calibration certificate) or field calibrated.

Each CO₂ sensor is wired correctly to the controls to ensure proper control of the outdoor air damper.

Each CO₂ sensor is located correctly within the space 1 to 6 ft above the floor.

Interior CO₂ concentration setpoint is ≤600 ppm plus outdoor air CO₂ value if dynamically measured or ≤1000 ppm if no OSA sensor is provided.

A minimum OSA setting is provided whenever the system is in Occupied mode per §121(c)4E regardless of space CO₂ readings.

A maximum OSA damper position for DCV control can be established per the *Exception* to §121(c)4C, regardless of space CO₂ readings.

The outdoor air damper modulates open when the CO₂ concentration within the space exceeds setpoint,

The outdoor air damper modulates closed (toward minimum position) when the CO₂ concentration within the space is below setpoint.

Potential Issues and Cautions

Lock out the economizer control during the test. Outdoor air damper may not modulate correctly if the economizer control strategy is controlling damper operation.

Overall test time may be reduced (especially for rooftop HVAC units) if two people perform the test - one to vary the CO₂ concentration while someone else verifies operation of the outdoor air dampers.

During the testing of the DCV controls, the outside damper will modulate open. Care should be taken to prevent freezing of coils when testing with cold temperatures outside.

10.7.16 Test Procedure: NA7.5.5 Demand Controlled Ventilation Systems Acceptance, Use Form MECH-6A

Test Comments and Applicability

The Standards require that only HVAC systems with the following characteristics must employ demand Controlled ventilation:

2. Single-zone systems. The intent was to limit the demand Controlled ventilation requirement to systems that primarily serve spaces with variable occupancy. Keep in mind, however, that it is possible that a facility may have a majority of spaces with fixed occupancy and only a few variable occupancy zones that meet the requirement, but still must implement demand Controlled ventilation for those variable occupancy zones. Single-zone HVAC systems can include, but are not limited to: 1) constant volume packaged units with stand-alone economizer controllers (e.g., Honeywell W7340 Logic Module); or 2) constant volume systems with individual dampers/actuators and either stand-alone or centralized DDC control.
3. The HVAC system must have an economizer. The reason for this requirement is that the system must have the ability to modulate outdoor air flow.
4. Spaces served with specific use types or have the following occupancy densities, as described in the California Building Code (CBC) Chapter 10, must utilize DCV control:
 - a. Assembly areas, concentrated use (without fixed seating); or
 - b. Auction rooms; or
 - c. Assembly areas, less concentrated use; or
 - d. Occupancy density of 40 ft² per person or less. Occupancy density is calculated using CBC Section 1004.1.1 CBC for spaces without fixed seating and CBC Section 1004.7 for spaces with fixed seating. However, classrooms are exempt from the demand Controlled ventilation requirement.

The Standards state that the system will maintain a minimum ventilation flow rate no less than the value calculated per §121(c)4E.

Construction Inspection

1. The CO₂ sensor is located within the control zone(s) between 3 ft and 6 ft above the floor or at the anticipated level of the occupant's heads. This is the critical range for measuring CO₂ since most occupants will be typically either sitting or standing within the space.
2. CO₂ sensor is either factory calibrated or field calibrated. A calibration certificate from the manufacturer will satisfy this requirement. In order to perform a field calibration check, follow the calibration procedures provided by the manufacturer. Some sensor manufacturers may require using equipment-specific calibration kits (kits may include trace gas samples and other hand-held devices) whereas others may be calibrated simply by using a pre-calibrated hand-held CO₂ measuring device and making proper adjustments through the sensor or ventilation controller.
3. Interior CO₂ concentration setpoint is ≤ 600 ppm plus outdoor air CO₂ value if outside concentration is measured dynamically. Else setpoint is ≤ 1000 ppm. Outdoor air CO₂ concentration can be determined by three methods: 1) assume a value of 400 ppm without any direct measurement; 2) measure outside concentration dynamically to continually adjust interior concentration setpoint; or 3) measure outside concentration one time during system checkout and use this value continually to determine inside concentration setpoint.

Functional Testing

Step 1: Disable the economizer.

Disabling the economizer will prevent the outdoor air damper from modulating during the test due to atmospheric conditions rather than CO₂ variations. The economizer can be disabled in a number of ways depending on the control strategy used to modulate the outdoor air dampers; however the simplest method would be to change the economizer changeover setpoint below current atmospheric conditions. The changeover setpoint is the value that will lock out the economizer, example control strategies include:

- Outdoor air dry-bulb temperature or enthalpy
- Comparison between outside and return air temperature or enthalpy

Step 2: Simulate a high space occupancy.

The intent of this test is to ensure the outdoor air damper modulates open when the CO₂ concentration within the space exceeds setpoint. Simulating a high space occupancy can be accomplished by, but not limited to: 1) commanding the setpoint value to be slightly below current concentration level; or 2) exposing the sensor to a known concentration of source gas (i.e. canister of CO₂ gas with a concentration greater than setpoint). In all cases you should endeavor to simulate a condition just slightly above the current CO₂ setpoint. Regardless of the method used to simulate a high CO₂ load, ensure the condition persists long enough for the HVAC system to respond.

Verify and Document

Ensure the outdoor air damper modulates open. If the CO₂ setpoint is lowered just below current concentration levels, the outdoor air damper will modulate open and the increased outdoor air should bring interior concentrations down to meet and maintain the new setpoint. If a known concentration of CO₂ gas was used to simulate an elevated concentration, then the outdoor air damper may modulate fully open since the “measured” concentration will not be influenced by the increase in outdoor air (Note that §121(c)4C states that outdoor ventilation rate is not required to exceed design minimum value calculated in §121(b)2, regardless of CO₂ concentration. Therefore, the outdoor air damper may only open to a position that provides the design minimum flow rate). If an unknown concentration was used to simulate a high load, then the outdoor air damper could modulate open and closed since the “measured” concentration may vary considerably throughout the test.

Step 3: Simulate a low occupant density.

The intent of this test is to ensure the outdoor air damper modulates towards minimum position when the CO₂ concentration within the space is below setpoint. Eventually the outdoor air damper should close to a position that provides minimum ventilation flow rate per §121(c)4E, regardless of how far the measured interior concentration is below setpoint. Simulating a low occupant density can be accomplished by, but not limited to: 1) commanding the setpoint value to be significantly higher than current concentration level; 2) exposing the sensor to a known concentration of source gas (i.e. canister of CO₂ gas with a concentration less than setpoint); or open doors and windows to reduce CO₂ concentration in the space. In each case you want the CO₂ reading to be well below the setpoint. Regardless of the method used to simulate a low occupant density, ensure the condition persists long enough for the HVAC system to respond.

Verify and Document

Ensure the outdoor air damper modulates towards minimum position. If setpoint is raised just above current concentration levels, the outdoor air damper will modulate closed and the reduced outdoor air should bring interior concentrations up to meet and maintain the new setpoint. If necessary, continue to adjust the setpoint upward until the outdoor air damper closes to a minimum position. If a known concentration of CO₂ gas was used to simulate a lowered concentration, then the outdoor air damper will most likely modulate to minimum position since the “measured” concentration will not be influenced by the decrease in outdoor air.

Step 4: Return system back to normal operating condition.

Ensure all schedules, setpoints, operating conditions, and control parameters are placed back at their initial conditions.

10.7.17 NA7.5.6 Supply Fan Variable Flow Controls Acceptance

At-A-Glance**NA7.5.6 Supply Fan Variable Flow Controls Acceptance****Use Form MECH-7A****Purpose of the Test**

The purpose of the test is to ensure that the supply fan in a variable air volume application modulates to meet system airflow demand. In most applications, the individual variable air valve (VAV) boxes serving each space will modulate the amount of air delivered to the space based on heating and cooling requirements. As a result, the total supply airflow provided by the central air handling unit must also vary to maintain sufficient airflow through each VAV box. Airflow is typically controlled using a variable frequency drive (VFD) to modulate supply fan speed and vary system airflow. The most common strategy for controlling the VFD is to measure and maintain static pressure within the duct.

Related acceptance tests for these systems include the following:

- NA7.5.1.1 Variable Air Volume Systems Outdoor Air Acceptance

Instrumentation

The instrumentation needed to perform the task may include, but is not limited to:

- Differential pressure gauge
- If applicable, supply air temperature reset should be disabled during testing to prevent any unwanted interaction.
- All systems and components must be installed and ready for system operation, including:
 - Duct work
 - VAV boxes
 - Static pressure sensor(s) (note multiple sensors with separate control loops are often used on large systems with multiple branches)
 - Electrical power to air handling unit
 - Air handling unit start-up procedures are complete, per manufacturer's recommendations

Test Conditions

BAS programming for the operation of the air handling unit and VAV boxes must be complete, including but not limited to:

- Supply fan VFD control
- VAV box control (including zone temperature sensors and maximum/minimum flow rates)
- Before testing, ensure all schedules, setpoints, operating conditions, and control parameters are documented. All systems must be returned to normal at the end of the test.

<ul style="list-style-type: none"> This test can and should be performed in conjunction with NA7.5.1.1 Variable Air Volume Systems Outdoor Air Acceptance test procedures.
Estimated Time to Complete
<p>Construction inspection: 0.5 to 1.5 hours (depending on sensor calibration and minimum VFD speed verification)</p> <p>Functional testing: 1 to 2 hours (depending on how total fan power at design airflow is determined and system control stability)</p>
Acceptance Criteria
<p>Static pressure sensor(s) is factory calibrated (with calibration certificate) or field calibrated.</p> <p>For systems without DDC controls to the zone level the pressure sensor setpoint is less than 1/3 of the supply fan design static pressure.</p> <p>For systems with DDC controls with VAV boxes reporting to the central control panel, the pressure setpoint is reset by zone demand (box damper position or a trim and respond algorithm).</p> <p>At full flow:</p> <ul style="list-style-type: none"> Supply fan maintains discharge static pressure within ± 10 percent of the current operating control static pressure setpoint Supply fan controls stabilizes within 5 minute period. At minimum flow (at least 30 percent of total design flow): Supply fan controls modulate to decrease capacity. Current operating setpoint has decreased (for systems with DDC to the zone level) Supply fan maintains discharge static pressure within ± 10 percent of the current operating setpoint.
Potential Issues and Cautions
<p>Ensure that all disabled reset sequences are enabled upon completion of this test.</p> <p>Coordinate test procedures with the controls contractor since they may be needed to assist with manipulation of the BAS to achieve the desired operating conditions.</p>

10.7.18 Test Procedure: NA7.5.6 Supply Fan Variable Flow Controls Acceptance, Use Form MECH-7A

Construction Inspection

Discharge static pressure sensor is factory calibrated or field calibrated. Calibration certificates from the manufacturer are acceptable. Performing a field calibration check requires measuring static pressure as close to the existing sensor as possible using a calibrated hand-held measuring device and comparing the field measured value to the value measured by the BAS (building automation system). If the value measured by the BAS is within 10 percent of the field-measured value, the sensor is considered calibrated.

Functional Testing

Supply air temperature reset should be disabled during testing to prevent any unwanted interaction.

Step 1: Drive all VAV boxes to achieve full airflow.

The intent is to verify proper supply fan operation at or near full flow condition. This typically occurs when all of the VAV boxes are operating at maximum cooling flow rate. There are a variety of ways to force the VAV boxes to a maximum cooling position depending on the building automation system capabilities and control strategies used, for example:

- Command all VAV boxes to maximum flow position (may be accomplished by a global command or it may have to be done per individual box or zone thermostat).
- Space temperature setpoint can be lowered below current space conditions to force the VAV box into maximum cooling (may be accomplished by a global command or it may have to be done per individual box or zone thermostat).

For this test, you cannot simply adjust the fan VFD to a maximum speed since the purpose of the test is to show the stability of the pressure control loop that automatically controls the fan speed. The fan speed must be in AUTO to discern this.

Verify and Document

- Supply fan maintains discharge static pressure setpoint within ± 10 percent of the current operating set point. Verification can be accomplished by simply reading the value measured by calibrated pressure sensor and comparing it to setpoint.
- System operation stabilizes within 5 minutes. The intent is to ensure the PID control loops are tuned properly so that the system does not hunt.

Step 2: Drive all VAV boxes to a low airflow condition.

The intent is to verify proper supply fan operation when the system is at or near minimum flow conditions. This typically occurs when all of the VAV boxes are operating at minimum cooling flow rate. There are a variety of ways to force the VAV boxes to a minimum position depending on the building automation system capabilities and control strategies used, for example:

- Command all VAV boxes to minimum flow position (may be accomplished by a global command or it may have to be done per individual box).
- Set maximum flow setpoint to be the same as minimum flow setpoint (may be accomplished by a global command or it may have to be done per individual box).
- Space temperature setpoint can be raised above current space conditions to force the VAV box into minimum cooling or heating mode (may be accomplished by a global command or it may have to be done per individual box or per zone thermostat).

Again, you cannot simply override the VFD as it would negate the purpose of the test.

Verify and Document

- VFD reduces supply fan speed to meet flow conditions.
- Supply fan maintains discharge static pressure setpoint within ± 10 percent of the current operating set point. Verification can be accomplished by simply reading the value measured by calibrated pressure sensor and comparing it to setpoint.
- System operation stabilizes within 5 minutes. The intent is to ensure the PID control loops are tuned properly so that the system does not hunt.

Step 3: Return system back to normal operating condition.

Ensure all schedules, setpoints, operating conditions, and control parameters are placed back at their initial conditions.

10.7.19 NA7.5.7 Valve Leakage Acceptance

At-A-Glance

NA7.5.7 Valve Leakage Acceptance

Use Form MECH-8A

Purpose of the Test

The purpose of this test is to ensure that control valves serving variable flow systems are designed to withstand the pump pressure over the full range of operation. Valves with insufficient actuators will lift under certain conditions causing water to leak through and loss of control. This test applies to the variable flow systems covered by §144(j)1 Chilled and hot-water variable flow systems, §144(j)2 chiller isolation valves, §144(j)3 boiler isolation valves, and §144(j)4 water-cooled air conditioner and hydronic heat pump systems.

Related acceptance tests for these systems include the following:

- NA7.5.9 Hydronic System Variable Flow Control Acceptance

Testing time will be greatly reduced if these acceptance tests are done simultaneously.

Instrumentation

Performance of this test will require measuring differential pressure across pumps. The instrumentation needed to perform the task may include, but is not limited to:

- Differential pressure gauge or
- Handheld hydronic manometer

For accurate comparison with the pump curves it is important that you use the taps on the pump casing for these measurements. Taps on the inlet and discharge piping to the pumps will not correlate to the pump curves.

Test Conditions
<p>The whole hydronic system must be complete – all coils, control valves, and pumps installed; all piping is pressure tested, flushed, cleaned, filled with water; BAS controls, if applicable.</p> <p>All equipment start-up procedures are complete, per manufacturer's recommendations.</p> <p>Document the initial conditions before overrides or manipulation of the BAS. All systems must be returned to normal at the end of the test.</p>
Estimated Time to Complete
<p>Construction inspection: 0.5 to 2 hours (depending on availability of construction documentation and complexity of the system.)</p> <p>Functional testing: 30 minutes to 3 hours (depending on the complexity of the system and the number of valves)</p>
Acceptance Criteria
<p>Provisions have been made for variable flow:</p> <p>System has no flow when all coils are closed and the pump is turned on.</p>
Potential Issues and Cautions
<p>The Acceptance Agent will likely need access to the EMCS during testing</p> <p>Running a pump in a "deadhead" condition (no flow) for more than 5 minutes can damage the pump seals or motor. Care must be taken to set up the test so that the pump only needs to run for 5 minutes or less.</p> <p>If balance valves are used for isolation of three-way valves or pumps, their initial position must be noted prior to using them for shut off of flow so that they can be returned to their initial position at the end of the test.</p>

Scope of test

This test is required for the variable flow systems covered by §144(j)1 Chilled and hot-water variable flow systems, §144(j)2 chiller isolation valves, §144(j)3 boiler isolation valves, and §144(j)4 water-cooled air conditioner and hydronic heat pump systems.

No Flow Measurement.

10.7.20 Test Procedure: NA7.5.9 Valve Leakage Test, Use Form MECH-8A)

Construction Inspection

- Collect the pump curve submittal and note the impeller size. This establishes the curve that the pump should be operating on. It is not uncommon to find that a pump shipped with a different impeller even though the correct impeller is indicated on the plate of the pump.
- Ensure all valve and piping arrangements were installed per the design drawings in order to achieve the desired control. This refers to each heat exchanger or coil having its own two-way control valve, flow measuring

devices, if applicable, are located adequately to achieve accurate measurements (i.e. sufficient straight-line piping before and after the meter), and the piping arrangements are correct (for example there may be three-way valves located at one or more of the coils to ensure system minimum flow rates can be achieved).

Functional Testing

Step 1: Deadhead One Pump.

The intent of this test is to establish a baseline pump pressure for use in checking the ability of all valves to close across the system. Use manual isolation or balance valves at the inlet or bypass of all three way valves and close it off. If a balance valve is used mark its current position so that it can be reset after the test.

Isolate one circulation pump and make sure that all chillers or boilers are off. Close off the isolation valve at the pumps discharge and turn the pump on for not more than 5 minutes. Measure and note the pressure across the pump at this “deadhead” condition. If the system is piped primary/secondary make sure this is a secondary pump. At the end of the measurement turn off the pump and open the discharge valve at the pump.

Verify and Document

Step 2: Close control valves.

The intent of this test is to ensure that all two-way valves can modulate fully closed and have actuators that can fully close across an operating pump. With the chillers or boiler still off, start the same pump that was used in Step 1 and drive all HX or coil control valves closed. Closing the control valves can be achieved in a variety of ways, examples of which include: resetting control setpoints so that valves respond accordingly; commanding the valves directly using the DDC control system (i.e., building automation system); or applying a fixed amount of air pressure to an actuator or valve in the case of a pneumatic control system. Make sure that the pump operates for no more than 5 minutes in this “deadhead” condition.

Verify and Document

- Ensure each control valve closes completely under normal operating pressure. The intent is to make sure that the actuator-valve torque requirements are adequate to shut the valve under normal operating system pressure. Verifying complete closure shall be done by measuring the pressure across the operating pump. If the pressure is more than 5% less than that previously measured the test fails as one or more valves have not fully closed. Diagnose and fix the problem then retest.

Step 3: Return system back to normal operating condition.

Ensure all schedules, setpoints, isolation and balance valves, operating conditions, and control parameters are placed back at their initial conditions.

10.7.21 NA7.5.8 Supply Water Temperature Reset Controls Acceptance

At-A-Glance

NA7.5.8 Supply Water Temperature Reset Controls Acceptance

Use Form MECH-9A

Purpose of the Test

The intent of the test is to ensure that both the chilled water and hot water supply temperatures are automatically reset based on either building loads or outdoor air temperature, as indicated in the control sequences. Many HVAC systems are served by central chilled and heating hot water plants. The supply water operating temperatures must meet peak loads when the system is operating at design conditions. As the loads vary, the supply water temperatures can be adjusted to satisfy the new operating conditions. Typically the chilled water supply temperature can be raised as the cooling load decreases, and heating hot water supply temperature can be lowered as the heating load decreases.

This requirement only applies to chilled and hot water systems that are not designed for variable flow and that have a design capacity greater than or equal to 500 kBtuh (thousand BTU's per hour).

Instrumentation

Performance of this test will require measuring water temperatures as well as possibly air temperatures. The instrumentation needed to perform the task may include, but is not limited to:

- Hand-held temperature probe

Test Conditions

To perform the test, it may be necessary to use the building automation system (BAS) to manipulate system operation to achieve the desired control. BAS programming for the operation of the chillers, boilers, air handling units, and pumps must be complete, including but not limited to:

- Supply water temperature control
- Equipment start-stop control
- All control sensors installed and calibrated
- Control loops are tuned

All systems must be installed and ready for system operation, including:

- Chillers, boilers, pumps, air handling units, valves, piping, etc.
- All piping is pressure tested, flushed, cleaned, and filled with water
- Control sensors (temperature, humidity, flow, pressure, etc.)
- Electrical power to all equipment

Start-up procedures for all pieces of equipment are complete, per manufacturer's recommendations

Document the initial conditions before overrides or manipulation of the BAS. All systems must be returned to normal at the end of the test.

Estimated Time to Complete
<p>Construction inspection: 0.5 to 1 hours (depending on availability of construction documentation (i.e. plumbing drawings, material cut sheets, specifications, etc) as well as sensor calibration.)</p> <p>Functional testing: 1 to 2 hours (depending on familiarity with BAS, method employed to vary operating parameters, and time interval between control command and system response)</p>
Acceptance Criteria
<p>Supply water temperature sensors are either factory calibrated (with calibration certificates) or field calibrated.</p> <p>Sensor performance complies with specifications.</p> <p>Supply water reset works.</p>
Potential Problems and Cautions
<p>If the heating hot water temperature reset is tested when there is minimal heating load, make sure to test the low end of the reset first (coldest hot water supply temperature). If the hottest supply water temperature is tested first, it could be difficult to dissipate the heat in the hot water loop without artificially creating a heating load. Waiting for a small heating load to dissipate the heat in the loop could add significant time to the test procedure.</p> <p>Where humidity control is required, chilled water supply water reset is not recommended.</p>

10.7.22 Test Procedure: NA7.5.8 Supply Water Temperature Reset Controls
Acceptance, Use Form MECH-9A

Test Comments

The most common control variables used to reset supply water temperature setpoint include, but are not limited to: coil valve position; outdoor air temperature; and space conditioning parameters like humidity. Examples of each control strategy are provided below.

- Coil valve position.** A central energy management system is used to monitor cooling coil and/or heating coil valve positions to determine when the supply water temperature can be reset. The following example highlights a common heating hot water control strategy, in which all heating coil valve positions (central heating and re-heat coils) are monitored to determine current valve position. If all heating valves are less than 94 percent open, then the hot water supply temperature will be incrementally lowered until one valve opens to 94 percent and then the setpoint is maintained. If any valve opens to more than 98 percent open, then the hot water supply temperature will be incrementally raised and maintained until one valve drops back down to 94 percent open. A similar control strategy can be used to reset the chilled water supply temperature. The chilled and hot water temperature setpoint values will be determined by the designer and should be available from, the design narrative, specifications or control drawings.

- **Outdoor air temperature.** Another very common control strategy is to reset supply water temperature based on outdoor air temperature. Depending on the building type, internal loads and design conditions, the designer may develop a relationship between the chilled and hot water supply temperatures necessary to satisfy building loads at various outdoor air temperatures. For example, hot water temperature may be reset linearly between 90°F and 140°F when the outdoor air temperature is above 50°F and below 35°F, respectively. Actual supply water and outdoor air temperatures will be determined by the designer and should be available from, the design narrative, specifications or control drawings.
- **Humidity control.** For special applications like hospitals, museums, semiconductor fabrication and laboratories, the cooling coil control may be based on maintaining a constant relative humidity within the space for not only comfort but also indoor air quality and moisture control (i.e. mold issues). Therefore, the temperature of the chilled water delivered to the coil should be sufficient to remove moisture from the supply air stream and the chilled water temperature can be reset upwards as the latent load decreases. Actual chilled water temperature setpoint reset schedule will be determined by the designer and should be available from, the design narrative, specifications or control drawings.

Construction Inspection

Temperature sensors are either factory calibrated or field calibrated. Depending on the control strategy used to reset supply water temperature, sensors can include, but are not limited to: 1) supply water temperature sensor; and outdoor air temperature sensor (if used for reset). Calibration certificates from the manufacturer are acceptable. Field calibration requires using either a secondary temperature reference or placing the sensor in a known temperature environment (typically either an ice water or a calibrated dry-well bath). When field calibrating temperature sensors, it is recommended that you perform a “through system” calibration that compares the reference reading to the reading at the EMCS front end or inside the controller (e.g. it includes any signal degradation due to wiring and transducer error).

Functional Testing

Step 1. Change reset control variable to its maximum value.

Manually change the control variable in order to reset supply water temperature. For a valve position control strategy, command at least one coil valve to 100 percent open. An alternate method would be to adjust discharge air temperature or zone temperature setpoints to drive a valve into a 100 percent open condition. For an outdoor air temperature control strategy, override actual outdoor air sensor to exceed maximum water temperature boundary value. For example, if the control strategy calls for 42°F chilled water when outdoor air temperature is above 70°F, command the sensor to read 72°F. For a humidity control sequence, command the humidity setpoint to be 5 percent below actual humidity conditions.

Verify and Document

- Chilled and/or heating hot water supply temperature setpoint is reset to the appropriate value determined by the designer per the control strategy.
- Actual supply water temperature changes to meet the new setpoint. It may take a few minutes for the water temperature to change depending on system conditions and equipment operation.
- Verify that the supply temperature is within 2 percent of the control setpoint.

Step 2. Change reset variable to its minimum value.

Manually change the control variable in order to reset supply water temperature. For a valve position control strategy, command all coil valves to only be partially open. Continuing with one of the examples above, if supply water temperature is reset when a valve is less than 94 percent open, command all valves to be 90 percent open. An alternate method would be to adjust discharge air temperature or zone temperature setpoints to drive a valve into a partially open condition. For an outdoor air temperature control strategy, override actual outdoor air sensor to exceed minimum water temperature boundary value. For example, if the control strategy calls for 90°F heating water when outdoor air temperature is above 50°F, command the sensor to read 52°F.

Verify and Document

- Chilled and/or heating hot water supply temperature setpoint is reset to the appropriate value determined by the designer per the control strategy.
- Actual supply water temperature changes to meet the new setpoint. It may take a few minutes for the water temperature to change depending on system conditions and equipment operation.
- Verify that the supply temperature is within 2 percent of the control setpoint.

Step 3: Restore reset control variable to automatic control.

Ensure all schedules, setpoints, operating conditions, and control parameters are placed back at their initial conditions.

Verify and Document

- Chilled and/or heating hot water supply set-point is reset to the appropriate value.
- Actual supply temperature changes to meet the setpoint. It may take a few minutes for the water temperature to change depending on system conditions and equipment operation.
- Verify that the supply temperature is within 2 percent of the control setpoint.

10.7.23 NA7.5.9 Hydronic System Variable Flow Control Acceptance

At-A-Glance

NA7.5.9 Hydronic System Variable Flow Control Acceptance

Use Form MECH-10A

Purpose of the Test

All hydronic variable flow chilled water and water-loop heat pump systems with circulating pumps larger than 5 hp shall vary system flow rate by modulating pump speed using a variable frequency drive (VFD) or equivalent. As the loads within the building fluctuate, control valves should modulate the amount of water passing through each coil and add or remove the desired amount of energy from the air stream to satisfy the load. In the case of water-loop heat pumps, each two-way control valve associated with a heat pump will be closed when that unit is not operating. The purpose of the test is to ensure that, as each control valve modulates, the pump variable frequency drive (VFD) responds accordingly to meet system water flow requirements.

Note, this is not required on heating hot water systems with variable flow designs or for condensing water serving only water cooled chillers.

Related acceptance tests for these systems include the following:

- NA7.5.7 Valve Leakage Test (if applicable)

Instrumentation

The instrumentation needed to perform the task may include, but is not limited to:

- Differential pressure gauge

Test Conditions

To perform the test, it will be necessary to use the control system to manipulate system operation to achieve the desired control. At a minimum, control system programming for the operation of the central equipment, control valves, and pumps must be complete, including, but not limited to:

- Equipment start-stop control
- All control sensors installed and calibrated
- Control loops are tuned

All systems must be installed and ready for system operation, including:

- Heat pumps, cooling towers, boilers, pumps, control valves, piping, etc.
- All piping is pressure tested, flushed, cleaned, and filled with water
- Control sensors (temperature, flow, pressure, etc.)
- Electrical power to all equipment

Start-up procedures for all pieces of equipment are complete, per manufacturer's recommendations

Document the initial conditions before overrides or manipulation of the BAS. All systems must be returned to normal at the end of the test.

Estimated Time to Complete
<p>Construction inspection: 0.5 to 1 hour (depending on availability of construction documentation – i.e. plumbing drawings, material cut sheets, specifications, etc – as well as sensor calibration)</p> <p>Functional testing: 2 to 4 hours (depending on familiarity with BAS, method employed to vary operating parameters, verification method for system flow and VFD power)</p>
Acceptance Criteria
<p>Differential pressure sensor is either factory calibrated (with calibration certificates) or field calibrated.</p> <p>Pressure sensor is located at or near the most remote HX or control valve.</p> <p>System controls to the setpoint stably.</p>
Potential Problems and Cautions
<p>Difficulties could be encountered with manipulating the control system if not familiar with the programming language. Therefore, a controls contractor should be on-site to assist with adjusting system operation and overriding controls.</p>

10.7.24 Test Procedure: NA7.5.9 Hydronic System Variable Flow Control
Acceptance , Use Form MECH-10A

Test Comments

§144(j)6 permits two general variable flow control strategies: supply pressure reset by coil demand for systems with DDC controls to the coil level and fixed pressure setpoint control for all others.

It is recommended that minimum VFD speed setpoint be verified. If the minimum speed is below 6Hz (10 percent) the pump motor might overheat. However, if the minimum speed is too high, the system will not be allowed to turn down and the full energy savings of the VFD will not be achieved. To achieve the highest energy savings the minimum speed should be between 6Hz and 10Hz for variable flow systems. It is important to note that this minimum speed can be provided in the EMCS or at the VSD. It should be provided at only one or the other as providing it on both sometimes causes a cumulative minimum that is much larger than the one intended.

Construction Inspection

The differential pressure sensor (if applicable) is either factory calibrated or field calibrated. Calibration certificates from the manufacturer are acceptable. Field calibration would require measuring system pressure, or differential pressure, as close to the existing sensor as possible using a calibrated hand-held measuring device and comparing the field measured value to the value measured by the building automation system (BAS).

Functional Testing

It is acceptable to use this method to verify VFD operation even if the control does have a flow meter. This method compares VFD speed and pressure at full and minimum flow. If at minimum flow, VFD speed is decreased and system pressure is no greater than at full flow, the system is compliant.

Step 1 Open control valves to increase water flow to a minimum of 90 percent design flow.

Open control valves to reach between 90 and 100 percent of design flow. Opening the control valves can be achieved in a variety of ways, such as: resetting control setpoints so that valves respond accordingly, commanding the valves directly using the DDC control system (i.e., building automation system), or applying a fixed amount of air pressure to an actuator or valve in the case of a pneumatic control system.

Verify and Document

- System pressure is either within 5 percent of current operating setpoint or the pressure is below the setpoint and the pumps are operating at 100 percent speed.
- System operation stabilizes within 5 minutes after test procedures are initiated.

Step 2 Modulate control valves to reduce water flow to 50 percent of the design flow or less, but not lower than the pump minimum flow.

Modulating control valves can be accomplished by simply commanding each valve to a specific position or by adjusting temperature setpoints to be within the existing temperature range.

Verify and Document

- Current operating setpoint has decreased (for systems with DDC to the zone level).
- Current operating setpoint has not increased (for all other systems).
- System pressure is within 5 percent of current operating setpoint.
- System operation stabilizes within 5 minutes after test procedures are initiated.

At-A-Glance**NA7.5.10 Automatic Demand Shed Control Acceptance****Use Form MECH-11A****Purpose of the Test**

All control systems with DDC to the zone level are required to enable centralized demand shed at non-critical control zones from a single software or hardware point in the system §122(h). Field studies have shown that in typical commercial buildings resetting the zone temperatures up by 2°F to 4°F during on-peak times can reduce the peak electrical cooling demand by as much as 30 percent. This test is to ensure that the central demand shed sequences have been properly programmed into the DDC system

Instrumentation

The instrumentation needed to perform the task may include, but is not limited to:

- The front end computer to the DDC system

Test Conditions

To perform the test, it will be necessary to use the control system to manipulate system operation to achieve the desired control. The entire HVAC and control system must be complete to perform this test.

Estimated Time to Complete

Construction inspection: 0.5 hour to review the EMCS programming

Functional testing: 0.5 to 1 hour (depending on familiarity with BAS)

Acceptance Criteria

The control system changes the setpoints of non-critical zones on activation of a single central hardware or software point then restores the initial setpoints when the point is released.

Potential Problems and Cautions

Difficulties could be encountered with manipulating the control system if not familiar with the programming language. Therefore, a controls contractor should be on-site to assist with the testing.

Construction Inspection

That the EMCS interface enable activation of the central demand shed controls.

Functional Testing

Step 1 Engage the global demand shed system.

This can be done by either jumping the digital contact or simply overriding its condition in the EMCS front end. Wait 5-10 minutes to let the changes take effect.

Verify and Document

- That the cooling setpoints in the non-critical spaces increase by the proper amount.
- That the cooling setpoints in the critical spaces do not change.

Step 2 Disengage the global demand shed system.

This can be done by either removing the jumper from the digital contact or simply releasing the override of the point in the EMCS front end. Wait 5-10 minutes to let the changes take effect.

Verify and Document

- That the cooling setpoints in the non-critical spaces return to their original setpoint.
- That the cooling setpoints in the critical spaces do not change.

10.7.27 NA7.5.11 Fault Detection and Diagnostics (FDD) for Packaged Direct-Expansion (DX) Units Control Acceptance

At-A-Glance

NA7.5.11 Fault Detection and Diagnostics (FDD) for Packaged Direct-Expansion (DX) Units Acceptance

Use Form MECH-12A

Purpose of the Test

The purpose of this test is to verify proper fault detection and reporting for automated fault detection and diagnostics systems for packaged units. Automated FDD systems ensure proper equipment operation by identifying and diagnosing common equipment problems such as improper refrigerant charge, low airflow or faulty economizer operation. Qualifying FDD systems receive a compliance credit when using the performance approach. A system that does not meet the eligibility requirements may still be installed, but no compliance credit will be given.

Benefits of the Test

The test ensures that the FDD system can detect and report common faults such as an improper refrigerant charge or a reduction in airflow due to a dirty filter or coil. FDD systems help to maintain equipment efficiency closer to rated conditions over the life of the equipment.

Instrumentation
The system test for refrigerant charge requires no extra sensors, since the unit should be already equipped with suction and liquid line temperature and pressure sensors. The system test for airflow requires a fan flowmeter, flow grid or flow capture hood with accuracy to 7 percent of full airflow and static pressure transducer with accuracy to ± 0.2 Pa. Temperature sensor calibration requires a digital thermometer with accuracy of ± 0.1 percent of reading + 1.3°F and resolution to 0.2°F.
Test Conditions
<p>Packaged unit and thermostat installation and programming must be complete.</p> <p>HVAC system must be installed and ready for system operation, including completion of all start-up procedures, per manufacturer's recommendations.</p> <p>The system operating modes should already have been tested. If the system includes a field-installed air economizer, the economizer should already have been tested per procedures under forms MECH-2A.</p>
Estimated Time to Complete
<p>Construction inspection: 0.5 hour</p> <p>Functional testing: 1 to 2 hours</p> <p>FDD systems can have the capability to report alarms to a remote server, which are then accessible via a Web interface. It may be helpful to have two persons conducting the test – one to perform testing on the unit and a second to verify reporting of the alarm to the remote interface.</p>
Acceptance Criteria
<p>The system is able to detect a low airflow condition and report the fault.</p> <p>The system is able to detect if refrigerant charge is low or high and report the fault.</p>
Potential Problems and Cautions
<p>Compared to the pressure sensors, the temperature sensors can have a longer response time to reach a steady-state condition. Therefore, the FDD algorithms may have trouble working properly during transitional states – for example, when the fan or compressor first turns on. The tester should be aware of the potential for false alarms that may occur during testing.</p> <p>The refrigerant charge test is designed to detect a high or low refrigerant charge. If the charge is acceptable it is not necessary to force a low charge condition by removing refrigerant from the system.</p>

Construction Inspection

Prior to the functional testing the FDD hardware must be verified to have been installed on equipment by the manufacturer and that equipment make and model include factory-installed FDD hardware that match the information specified on the manufacturer's cut sheets and design plans.

Eligibility Criteria

A FDD system for DX packaged units shall contain the following features:

1. The unit must include a factory-installed economizer, and limit the economizer deadband to no more than 2°F. Field-installed economizers tend to be more prone to problems; factory-installed economizers will prevent the need to additional testing in the field.
2. The unit should include direct-drive actuators on outside air and return air dampers. Direct-drive actuators and gear-driven connections provide greater mechanical reliability than linkage driven systems that can become loose with wear and fall out of adjustment.
3. The unit shall include an integrated economizer with either differential dry-bulb or differential enthalpy control. Differential dry-bulb or enthalpy control provides greater energy savings than a fixed setpoint.
4. The unit shall include a low temperature lockout on the compressor to prevent coil freeze-up or comfort problems. This situation could occur during cold outside air conditions, or if the compressor continues to operate when the outside air temperature falls below 55°F. If the discharge air temperature falls below an adjustable setpoint (i.e. 40 to 45°F), the outside air dampers would modulate closed until the supply air temperature reaches the setpoint.
5. Outside air and return air dampers shall have maximum leakage rates conforming to ASHRAE 90.1-2004. Economizers, when fully open, often do not provide 100 percent outdoor air due to return air leakage. ASHRAE 90.1-2004 requires blade and jamb seals on outside air dampers for economizers. This also ensures that outside air dampers can close completely during pre-occupancy warm-up or setback periods.
6. The unit shall have an adjustable expansion control device such as a thermostatic expansion valve (TXV). Units equipped with TXVs or electronic expansion valves are more tolerant of changes in refrigerant charge and maintain efficiency over a wider range of charge conditions.
7. To improve the ability to troubleshoot charge and compressor operation, a high-pressure refrigerant port will be located on the liquid line. A low-pressure refrigerant port will be located on the suction line. Subcooling is determined by measuring the liquid line pressure and comparing the saturation temperature to the actual liquid temperature.
8. The following sensors should be permanently installed to monitor system operation and the controller should have the capability of displaying the value of each parameter:
 - a. Refrigerant suction pressure
 - b. Refrigerant suction temperature
 - c. Liquid line pressure

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- d. Liquid line temperature
 - e. Outside air temperature
 - f. Outside air relative humidity
 - g. Return air temperature
 - h. Return air relative humidity
 - i. Supply air temperature
 - j. Supply air relative humidity.

Having pressure sensors hardwired will eliminate the need to tap into the refrigerant circuit. Permanent temperature measurements will prevent inaccuracies caused by pipe surface measurements when the ambient temperature varies significantly from the refrigerant temperature. Note that the diagnostic techniques used by the FDD controller may eliminate the need for some of the sensors listed above.

The controller will provide system status by indicating the following conditions:

- Compressor enabled
- Economizer enabled
- Free cooling available
- Mixed air low limit cycle active
- Heating enabled.

The unit controller shall have the capability to manually initiate each operating mode so that the operation of compressors, economizers, fans, and heating system can be independently tested and verified. This will eliminate the need for using jumpers to initiate the different operating modes.

Functional Testing

1. **Test low airflow condition.** Packaged equipment is typically designed to operate in the airflow range of 350 to 400 cfm per ton of cooling. Lower airflows will reduce equipment performance.
 - a. Replace the existing filter with a dirty filter or obstruction to reduce the supply airflow. This can be done by either obstructing part of the filter media, or by installing a second filter in series with (in front of) the existing filter.
 - b. The system airflow may be tested using (i) supply plenum pressure matching, (ii) a flow grid measurement, or (iii) a flow capture hood measurement at the return grille(s) according to procedures in Section 3.3 of Reference Residential Appendix RA3.
 - i. For an airflow measurement using supply plenum pressure matching, the apparatus for measuring the system fan flow shall consist of a duct pressurization and flow measurement device (subsequently referred to as a fan flowmeter) meeting the specifications in RA3.3.1, a static pressure transducer meeting the specifications in RA3.3.1, and an air barrier between the return duct system and the air handler inlet.

1. The measuring device shall be attached at the air handler blower compartment door. All registers shall be in their normal operating condition. The static pressure probe shall be fixed, or alternatively at the inlet to a return from the conditioned space. The measuring device shall be attached at a point where all the fan airflow shall flow through it.
 2. When the air handler blower compartment door is used an air barrier must be placed between the return duct system and the air handler inlet(s). All registers shall be in their normal operating condition.
 3. The static pressure probe shall be fixed to the supply plenum at the location specified in RA3.3.1.1 of Reference Residential Appendix RA3 so that it is not moved during this test.
 4. With the system fan on at the maximum speed used in the installation, measure the pressure difference between the supply plenum and the conditioned space (P_{sp}). P_{sp} is the target pressure to be maintained during the tests.
 5. If the fan flowmeter is to be connected to the air handler at the access door, block the return duct system from the plenum upstream of the air handler fan and flowmeter.
 6. Attach the fan flowmeter at the air handler access, or alternatively at the inlet to the return from the conditioned space.
 7. Turn on the system fan and the fan flowmeter and adjust the flowmeter until the pressure between the supply plenum and conditioned space matches P_{sp} . Record the airflow through the flowmeter in cfm.
 8. If the system fan and flowmeter can not produce enough flow to reach P_{sp} , record the maximum flow (Q_{max}) and pressure (P_{max}) between the supply plenum and the conditioned space. Correction of the flowmeter reading to adjust for the difference between the test pressure and operating pressure is made by the following equation:
 - a. $Q_{ah} = Q_{max} \times (P_{sp}/P_{test})^{0.5}$
 - b. Where P_{sp} is the normal operating pressure and P_{test} is the static pressure with the flowmeter in place.
- ii. A flow capture hood may be used to measure airflow at the return register(s). The hood dimensions must be greater than the dimensions of the return grilles for this test. All registers should be fully open and the air filter should be installed. The flow hood should be calibrated with an accuracy level of 7 percent of fan flow or better.
 - iii. A flow grid and static pressure transducer may be used to measure system airflow. The grid should be positioned so that all airflow passes through the flow grid. A static pressure transducer is installed in the supply plenum in the location described in Reference Residential Appendix RA3.3.1.1. The transducer should have

accuracy to ± 0.2 Pa. Static pressure measurements are taken with and without the flow grid in place. Correction for pressure drop across the flow grid is handled by the following equation:

1. $Q_{ah} = Q_{max} \times (P_{sp}/P_{test})^{0.5}$

2. Where P_{sp} is the normal operating pressure and P_{test} is the static pressure with the flow grid in place.

- c. Divide the airflow by the nominal tons of the air conditioner. If the measured airflow is at least 10 percent lower than 350 cfm/ton, verify that the system reports a fault.
 - d. Restore the filter back to its original condition.
2. **Test refrigerant charge.** Refrigerant charge is commonly tested either through measurements of superheat or subcooling, or by direct weight measurement of the refrigerant. A superheat value that is higher than the design value for the system is an indication of low refrigerant charge. When the charge is low, the refrigerant in the evaporator boils off quickly and the remaining heat is transferred to the gas as superheat. Packaged systems with thermostatic expansion valves are designed to ensure a constant amount of superheat. Too much subcooling is an indication that the system is overcharged. A related indication is a discharge pressure that is too high, especially at high cooling loads.

The refrigerant charge test for systems equipped with thermostatic expansion valves or electronic expansion valves requires measurements of subcooling and superheat. Subcooling and superheat can be determined from suction line and liquid line pressure and temperature sensor readings.

- a. Determine the amount of subcooling by taking the difference between the liquid line temperature and the saturation temperature at the liquid line pressure. $Subcooling = T_{condenser,sat} - T_{liquid}$
- b. Determine the target subcooling specified by the manufacturer.
- c. Calculate the difference between the target subcooling and measured subcooling. If the difference is less than 4°F, the system passes.
- d. If the difference is greater than +4°F, the charge is too high and the installer should remove refrigerant. If the charge is too high verify that the FDD controller reports a fault.
- e. If the difference is less than -4°F, the charge is too low and the installer should add refrigerant. If the charge is too low, verify that the FDD controller reports a fault.
- f. Determine the superheat by taking the difference between the suction line temperature and the saturation temperature at the suction line pressure.

$$Superheat = T_{suction} - T_{evaporator,sat}$$

- g. Determine the target superheat specified by the manufacturer if the information is available.
- h. Calculate the difference between the target superheat and measured superheat. If the difference is within the manufacturer's superheat range, the system passes. If manufacturer data is not available, and the superheat is between 3°F and 30°F, the system passes.

- i. If the superheat is too high verify that the FDD controller reports a low charge fault. If the superheat is too low verify that the FDD controller reports a high charge fault.
3. Calibrate outside air, return air and mixed air temperature sensors.
 - a. Fill an insulated cup (foam) with crushed ice. The ice shall completely fill the cup. Add water to fill the cup.
 - b. Insert two sensors into the center of the ice bath and attach them to the digital thermometer.
 - c. Let the temperatures stabilize. The temperatures should be $32^{\circ}\text{F} \pm 1^{\circ}\text{F}$. If the temperature is off by more than 1°F , make corrections according to the manufacturer's instructions. If the temperature is off by more than 2°F , the sensors should be replaced.

10.7.28 NA7.5.12 FDD for Air Handling Units and Zone Terminal Units
Acceptance

At-A-Glance

NA7.5.12 Automatic Fault Detection Diagnostics (FDD) for Air Handling Units and Zone Terminal Units Acceptance

Use Form MECH-13A

Purpose of the Test

Fault detection and diagnostics can also be used to detect common faults with air handling units and zone terminal units. Many FDD tools are standalone software products that process trend data offline. Maintenance problems with built-up air handlers and variable air volume boxes are often not detected by energy management systems because the required data and analytical tools are not available. Because of the large volume of data requiring analysis it is more practical to perform the FDD analysis within the distributed unit controllers. The acceptance tests are designed to verify that the system detects common faults in air handling units and terminal units. FDD systems for air handling units and zone terminal units require DDC controls to the zone level. Successful completion of this test provides a compliance credit when using the performance approach. An FDD system that does not pass this test may still be installed, but no compliance credit will be given.

Benefits of the Test

The test will ensure that the FDD controls are able to detect and report common faults with air handling units and VAV boxes. Fan power consumption will be reduced due to proper operation of the air handler, as well as VAV boxes that are responding correctly to zone demand requirements. Cooling energy will be reduced due to proper operation of the VAV boxes since a VAV box that is providing too much air to a zone will end up overcooling the zone. This results in wasted energy on the heating side, since the reheat coil will then need to be activated.

Instrumentation

FDD tests for air handling units and zone terminal units require no additional instrumentation for testing, since control algorithms are embedded in unit controllers.

Test Conditions
The air handling unit should be installed and the heating, cooling and economizer modes of operation tested. To perform the test, it may be necessary to use the building automation system (BAS) to manipulate system operation to achieve the desired control. BAS programming for the operation of the chillers, boilers, air handling units, and pumps must be complete. All equipment startup procedures must have been completed per manufacturer's instructions. All control sensors must be installed and control loops tuned. Document the initial conditions before any overrides to the building automation system.
Estimated Time to Complete
Acceptance tests will take 1-2 hours for each air handler. It may be helpful to have two persons performing this test. Time for acceptance testing for terminal units depends on the number of boxes to be tested.
Acceptance Criteria
The system is able to detect common faults with air handling units, such as a sensor failure, a failed damper or actuator or an improper operating mode. The system is able to detect and report common faults with zone terminal units, such as a failed damper or actuator or a control tuning issue.
Potential Problems and Cautions
Difficulties could be encountered with manipulating the control system if not familiar with the programming language. Therefore, a controls contractor should be on-site to assist with the testing.

Functional Testing

Air Handling Unit Tests

Testing of each AHU with FDD controls shall include the following tests.

1. **Sensor drift/failure:** The threshold for a sensor drift fault should be given in percentage of full range, or in units for each type of sensor (temperature, differential pressure / airflow rate, etc.) This tests the sensor fault by disconnecting the sensor.

Step 1: Disconnect outside air temperature sensor from unit controller.

Step 2: Verify that the FDD system reports a fault.

Step 3: Connect OAT sensor to the unit controller.

Step 4: Verify that FDD indicates normal system operation.
2. **Damper/actuator fault:** this includes a failed actuator, or a damper stuck in an open closed or fixed position.

Step 1: From the control system workstation, command the mixing box dampers to full open (100 percent outdoor air). This may be done by lowering the supply air temperature setpoint at the control workstation.

Step 2: Disconnect power to the actuator and verify that a fault is reported at the control workstation.

Step 3: Reconnect power to the actuator and command the mixing box dampers to full open by maintaining the supply air temperature setpoint.

Step 4: Verify that the control system does not report a fault.

Step 5: From the control system workstation, command the mixing box dampers to a minimum position (0 percent outdoor air). This may be done by raising the supply air temperature setpoint at the control workstation.

Step 6: Disconnect power to the actuator and verify that a fault is reported at the control workstation.

Step 7: Reconnect power to the actuator and command the dampers closed.

Step 8: Verify that the control system does not report a fault during normal operation.

3. **Valve/actuator fault:** this test covers faults such as actuator failure, a valve stuck in an open or closed position and valve leaks.

Step 1: From the control system workstation, command the heating coil valve to the full open position. This may be done by temporarily setting the space heating setpoint higher than the current space temperature, if the system is not in heating mode.

Step 2: Disconnect power to the actuator and verify that a fault is reported.

Step 3: Reconnect power to the actuator and command the heating coil valve to full open.

Step 4: Verify that the control system does not report a fault.

Step 5: From the control system workstation, command the cooling coil valve to the full open position. This may be done by temporarily setting the space cooling setpoint lower than the current space temperature, if the system is not in cooling mode.

Step 6: Disconnect power to the actuator and verify that a fault is reported.

Step 7: Reconnect power to the actuator and command the cooling coil valve to full open.

Step 8: Verify that the control system does not report a fault.

4. **Inappropriate simultaneous heating, mechanical cooling, and/or economizing:** these tests are designed to capture faults when the system is running in an improper mode of operation. (For systems with integrated economizers, economizer and cooling operation can be simultaneously enabled.)

Step 1: From the control system workstation, override the heating coil valve and verify that a fault is reported at the control workstation.

Step 2: From the control system workstation, override the cooling coil valve and verify that a fault is reported at the control workstation.

Step 3: From the control system workstation, override the mixing box dampers and verify that a fault is reported at the control workstation.

Functional Testing for Zone Terminal Units

Testing shall be performed on one of each type of terminal unit (VAV box) in the project. A minimum of 5 percent of the terminal units shall be tested.

1. Sensor drift/failure:

Step 1: Disconnect the tubing to the differential pressure sensor of the VAV box.

Step 2: Verify that control system detects and reports the fault.

Step 3: Reconnect the sensor and verify proper sensor operation.

Step 4: Verify that the control system does not report a fault.

2. Damper/actuator fault:

(a) Damper stuck open.

Step 1: Command the damper to be fully open. This may be done in a variety of ways, depending on the capabilities of the building automation system. Override the space temperature setpoint to be below the current space temperature to force the system into maximum cooling. Or, command the VAV box to the maximum position through the control workstation.

Step 2: Disconnect the actuator to the damper.

Step 3: Adjust the cooling setpoint so that the room temperature is below the cooling setpoint to command the damper to the minimum position. Verify that the control system reports a fault.

Step 4: Reconnect the actuator and restore to normal operation.

(b) Damper stuck closed.

Step 1: Set the damper to the minimum position.

Step 2: Disconnect the actuator to the damper.

Step 3: Set the cooling setpoint below the room temperature to simulate a call for cooling. Verify that the control system reports a fault.

Step 4: Reconnect the actuator and restore all setpoints to their original values to resume normal operation.

3. Valve/actuator fault: this fault could be caused by actuator failure or a valve stuck in an open or closed position. This test is only applicable to systems with hydronic reheat.

Step 1: Command the reheat coil valve to (full) open by setting the heating setpoint temperature above the space temperature

setpoint. Wait for the controls to respond to the command to open the reheat coil valve open.

Step 2: Disconnect power to the actuator. Set the heating setpoint temperature to be lower than the current space temperature, to command the valve closed. Verify that the fault is reported at the control workstation.

Step 3: Reconnect the actuator and restore all setpoints to their original values to resume normal operation.

4. **Feedback loop tuning fault:** this test is designed to capture a fault that might occur from excessive hunting or sluggish control.

Step 1: Set the integral coefficient of the box controller (reset action) used for airflow control to a value 50 times the current value. Reduce the space temperature setpoint to be 3°F below the current space temperature to simulate a call for cooling.

Step 2: The damper cycles continuously over a period of several minutes. (The cycling period time depends on the type of controller used but is typically on the order of a few minutes.) Verify that the control system detects and reports the fault.

Step 3: Reset the integral coefficient of the controller to its original value and reset the space setpoint to its original value to restore normal operation.

5. **Disconnected inlet duct:**

Step 1: From the control system workstation, command the damper to a minimum position (full closed) by raising the space temperature setpoint.

Step 2: Then disconnect power to the actuator and verify that a fault is reported at the control workstation.

Step 3: Reset the space temperature setpoint back to its original value.

10.7.29 NA7.5.13 Distributed Energy Storage DX AC System Acceptance

At-A-Glance

NA7.5.13 Distributed Energy Storage DX AC Acceptance Use Form MECH-14A

Purpose of the Test

This test verifies proper operation of distributed energy storage DX systems. Distributed energy systems reduce peak demand by operating during off peak hours and storing cooling, usually in the form of ice. During peak cooling hours the ice is melted to avoid compressor operation. The system typically consists of a water tank containing refrigerant coils that cool the water and convert it to ice. As with a standard direction expansion (DX) air conditioner, the refrigerant is compressed in a compressor and then cooled in an air-cooled condenser. The liquid refrigerant then is directed through the coils in the water tank to make ice or to air handler coils to cool the building.

Benefits of the Test
The test will ensure that the distributed energy storage system is able to charge the storage tank during off-peak hours and discharge the storage tank during on peak hours to reduce peak demand. Since the DX air conditioner can operate more efficiently at night when ambient temperatures are lower, the system may save cooling energy in some climates.
Instrumentation
Distributed energy storage acceptance tests require no additional instrumentation for testing.
Test Conditions
The DX equipment should be installed and operational. Perform pre-startup installation procedures as specified by the manufacturer. Verify that the building cooling is controlled by a standard indoor HVAC thermostat and not by factory installed controls. Verify that ice making is not controlled by the thermostat. The water tank should be filled to the proper level as specified by the manufacturer prior to the start of the test. All refrigerant piping field connections should be made and the system should be charged with refrigerant.
Estimated Time to Complete
Construction Inspection: 0.5 hours
Acceptance Tests: 2 hours
Acceptance Criteria
<p>Verify nighttime ice making operation.</p> <p>Verify that tank discharges during on-peak cooling periods.</p> <p>Verify that the compressor does not run and the tank does not discharge when there is no cooling demand during on-peak periods.</p> <p>Verify that the system does not operate during a morning shoulder period when there is no cooling demand.</p> <p>Verify that the system operates in direct mode (with compressor running) during the morning shoulder time period.</p>
Potential Problems and Cautions
These tests only apply to systems with storage capacity less than 100 ton-hours. Systems with storage above 100 ton-hours should be modeled using the thermal energy storage compliance option. Be sure the water tank is filled to the proper level indicated by the manufacturer prior to the start of the tests. The tests require override of the system controller programming. Be sure to record the system settings prior to the start of the testing, and restore the system settings to their original values upon completion of the tests.

Construction Inspection

The distributed energy storage system third party submittal form should be verified, which contains the following information: testing laboratory, address, phone number, contact person, date tested, tracking number, model number, and manufacturer. The following performance information should be recorded and reported on the form MECH-14A:

- The water tank is filled to the proper level.

- The water tank is sitting on a foundation with adequate structural strength.
- The water tank is insulated and the top cover is in place.
- The DES/DXAC is installed correctly (refrigerant piping, etc.).
- Verify that the correct model number is installed and configured.

Acceptance Tests

Step 1: Simulate cooling load during daytime period.

The intent of this test is to verify that during on-peak conditions the tank will discharge and the compressor will remain off.

Set the time clock to on-peak hours (typically between 12 noon and 6 PM), or change the on-peak start time control parameter to be earlier than the current time. Set the space cooling setpoint to be below the current space temperature.

Verify and document the following:

- Supply fan operates continually.
- If the system has storage of ice, verify that the DES/DXAC runs in ice melt mode and that the compressor remains off. The supply fan operates continuously to provide cooling to the space. The refrigerant pump operates to circulate refrigerant to the evaporator coil(s).
- If the DES/DXAC system has no ice and there is a call for cooling, verify that the DES/DXAC system runs in direct cooling mode, with the compressor running. Verify that cooling is provided to the space.

Step 2: Simulate no cooling load during daytime conditions by setting the cooling setpoint above the current space temperature, and set the system time to be within the daytime period.

Verify and document the following:

- Supply fan operates as per the facility thermostat or control system.
- The DES/DXAC and the condensing unit do not run.

Step 3: Simulate no cooling load during the morning shoulder time period (before noon).

Set the space temperature setpoint to be above the current space temperature and set the system time clock to be between the hours of 6AM and noon.

Verify and document the following:

- The DES/DXAC system remains idle.

Step 4: Simulate a cooling load during the morning shoulder time period (between 6 am and noon) by setting the space setpoint below the current space temperature.

Verify and document the following:

- Verify that the DES/DXAC system runs in direct cooling mode, with the compressor running. Verify that the tank does not discharge during this period.

Calibrating Controls

Set the date and time back to the current date and time after completion of the acceptance tests, following manufacturer's instructions.

10.7.30 NA7.5.14 Thermal Energy Storage (TES) System Acceptance

At-A-Glance

NA7.5.14 Thermal Energy Storage (TES) System Acceptance

Use Form MECH-15A

Purpose of the Test

This test verifies proper operation of thermal energy storage (TES) systems. TES systems reduce energy consumption during peak demand periods by shifting energy consumption to nighttime. Operation of the thermal energy storage compressor during the night produces cooling energy which is stored in the form of cooled fluid or ice in tanks. During peak cooling hours the thermal storage is used for cooling to prevent the need for chiller operation.

Benefits of the Test

The test will ensure that the TES system is able to charge the storage tank during off-peak hours and discharge the storage tank during on peak hours to reduce peak demand. Since the chiller can operate more efficiently at night when ambient temperatures are lower, the system may save cooling energy in some climates.

Instrumentation

TES acceptance tests require no additional instrumentation for testing.

Test Conditions

The chiller should be installed and operational. The thermal storage tank should be without charge or partially charged (not fully charged) at the start of testing. The system should be configured with an on-peak cooling period (tank discharge) of 12:00pm to 6:00pm and an off-peak charging period of 9:00pm to 9:00am. During 6:00pm to 9:00pm the cooling load can be met by storage if the tank has stored energy available or by compressor cooling if there is no stored energy available. Between 9:00am and 12:00pm the tank does not discharge and the cooling load is met by the compressor only.

Estimated Time to Complete

Construction Inspection: 0.5 hours

Acceptance Tests: 2 hours

Acceptance Criteria

Verify that the system is able to charge the storage tank during off-peak periods when there is no cooling load.

Verify that tank discharges during on-peak cooling periods.

Verify that the compressor does not run and the tank does not discharge when there is no cooling demand during on-peak periods.

Verify that the system does not operate during a morning shoulder period when there is no cooling demand.

Verify that the system operates in direct mode (with compressor running) during the morning shoulder time period.

Potential Problems and Cautions

Verify that if the design of the TES equipment includes a bypass that allows for direct chiller operation that it is designed so that if the bypass is used, the efficiency of the system will not be significantly reduced in comparison to a central chiller system with no TES.

Construction Inspection

Eligible systems for the TES compliance option include the following storage types: chilled water storage, ice-on-coil, ice harvester, Brine, ice-slurry, eutectic salt, or clathrate hydrate slurry (CHS).

The following information should be verified for the chiller and storage tank:

Chiller:

- Brand and Model
- Type (Centrifugal, Reciprocating, Other)
- Capacity (tons) (SIZE)
- Starting Efficiency (kW/ton) at beginning of ice production (COMP - KW/TON - START)
- Ending Efficiency (kW/ton) at end of ice production (COMP - KW/TON/END)
- Capacity Reduction (% /°F) (PER – COMP - REDUCT/F)

Storage Tank:

- Storage Type (TES-TYPE)
- Number of Tanks (SIZE)
- Storage Capacity per Tank (ton-hours) (SIZE)
- Storage Rate (tons) (COOL – STORE - RATE)
- Discharge Rate (tons) (COOL – SUPPLY - RATE)
- Auxiliary Power (watts) (PUMPS + AUX - KW)
- Tank Area (CTANK – LOSS - COEFF)
- Tank Insulation (R - Value) (CTANK – LOSS – COEFF)

The installing contractor shall certify the following information, which verifies proper installation of the TES System consistent with system design expectations:

- The TES system is one of the above eligible systems
- Initial charge rate of the storage tanks (tons)
- Final charge rate of the storage tank (tons)
- Initial discharge rate of the storage tanks (tons)
- Final discharge rate of the storage tank (tons)
- Charge test time (hrs)
- Discharge test time (hrs)
- Tank storage capacity after charge (ton-hrs)
- Tank storage capacity after discharge (ton-hrs)
- Tank standby storage losses (UA)
- Initial chiller efficiency (kW/ton) during charging
- Final chiller efficiency (kW/ton) during charging

Verify that the efficiency of the chiller meets or exceeds the requirements of §112.

Functional Testing

Step 1. Verify that the TES system and the chilled water plant is controlled and monitored by an energy management system (EMS).

Step 2. Force the time to be between 9:00 p.m. and 9:00 a.m. and simulate a partial or no charge of the tank and simulate no cooling load by setting the indoor temperature set point(s) higher than the ambient temperature.

If the tank is full or nearly full of ice, it may be necessary to adjust the control settings for this test. In some cases, the control system will not permit the chiller to start the ice-making process unless a portion of the ice has been melted. The controls designer may be using an inventory meter (a 4-20mA sensor that indicates water level) to determine whether or not ice-making can commence (for example, not allow ice-making unless the inventory meter signal is less than 17mA). If this is the case, this limit can be reset to 20mA during testing to allow ice making to occur.

Verify that the TES system starts charging (storing energy). This may be checked by verifying flow and inlet and outlet temperatures of the storage tank, or directly by reading an inventory meter if the system has one.

Step 3. Force the time to be between 6:00 p.m. and 9:00 p.m. and simulate a partial charge on the tank and simulate a cooling load by setting the indoor temperature set point lower than the ambient temperature. Verify that the TES system starts discharging. This may be checked by observing tank inlet and outlet temperatures and system flow, or directly by reading an inventory meter if the system has one. (If the system has no charge, verify that the system will still attempt to meet the load through storage.)

Step 4. Force the time to be between noon and 6:00 p.m. and simulate a cooling load by lowering the indoor air temperature set point below the ambient temperature. Verify that the tank starts discharging and the compressor is off.

Step 5. Force the time to be between 9:00 a.m. to noon, and simulate a cooling load by lowering the indoor air temperature set point below the ambient temperature. Verify that the tank does not discharge and the cooling load is met by the compressor only.

Step 6. Force the time to be between 9:00 p.m. and 9:00 a.m. and simulate a full tank charge. This can be done in a couple of ways: (1) by changing the inventory sensor limit that indicates tank capacity to the Energy Management System so that it indicates a full tank, or (2) by resetting the coolant temperature that indicates a full charge to a higher temperature than the current tank leaving temperature. Verify that the tank charging is stopped.

Step 7. Force the time to be between noon and 6:00 p.m. and simulate no cooling load by setting the indoor temperature set point above the ambient temperature. Verify that the tank does not discharge and the compressor is off.

10.8 Test Procedures for Indoor & Outdoor Lighting

This section includes test and verification procedures for lighting systems that require acceptance testing as listed below.

Form LTG-3A

- NA 7.6.1 Automatic Daylighting Controls Acceptance

Form LTG-2A

- NA 7.6.2 Occupancy Sensor Acceptance
- NA 7.6.3 Manual Daylight Controls Acceptance
- NA 7.6.4 Automatic Time Switch Control Acceptance

Form OLTG-2A

- NA 7.7.1 Outdoor Motion Sensor Acceptance

Form OLTG-3A

- NA 7.7.2 Outdoor Lighting Shut-off Controls

At-A-Glance

NA7.6.1 Automatic Daylighting Control Acceptance

Use Form LTG-3A

Purpose of the Test

The purpose of this test is to ensure that spaces mandated to have automatic daylighting control (refer to §131(c)) or those spaces receiving compliance credit for automatic daylighting controls (See §146(a)1e) are installed and functioning as required by the Standards.

Automatic daylighting controls in primary sidelit and skylit daylight areas greater than 2,500 ft² are mandatory and must have multiple stages of control that reduce lighting power by at least 65 percent (to no more of 35 percent of full power). Automatic daylighting controls in smaller primary sidelit and skylit daylight areas or in any size secondary sidelit daylight areas qualify for a lighting control credit and do not have to control all of the general lighting in the daylight zone.

Benefits of the Test

The controls save energy only if they are functioning correctly. Controls passing the test provide adequate illuminance under all daylight conditions while reducing lighting power enough in response to daylight in the space to save a significant fraction of lighting energy. If the control leaves the space too dark, visual quality is compromised and ultimately the control will be over-ridden resulting in no energy savings. If the control leaves lights on at too high an illuminance level, the full savings from the control are not realized.

Instrumentation

To perform the test, it will be necessary to measure ambient light level and validate overall power reduction. In most cases, the only instrumentation required is:

- Light meter (illuminance or foot-candle meter)

For dimming ballasts, a default illuminance/power relationship can be used to estimate power consumption.

Alternatively, the tester can choose to directly measure power or current or use the manufacturer's dimming performance data. Additional instrumentation or data that may be needed:

- Hand-held amperage meter or power meter
- Logging light meter or power meter
- Manufacturer's light versus power curve for continuous dimming and step dimming ballasts

Test Conditions

All luminaires in the daylit area must be wired and powered. Controls installed according to manufacturer's instructions

Simulating a bright condition can be difficult; therefore, performing the test under natural sunny conditions is preferable.

Document the initial conditions before testing. All systems must be returned to normal at the end of the test.

Estimated Time to Complete

Construction Inspection: 0.5 to 1 hour (depending on whether sensor calibration is necessary, familiarity with lighting control programming language, and availability of construction documentation – i.e. electrical drawings, material cut sheets, etc.)

Equipment Test: 1 to 3 hours (depending on ability to manipulate ambient light levels, familiarity with lighting control programming language, and method employed for verifying required power reduction)

Acceptance Criteria

Lighting is correctly circuited so that general lighting fixtures in the daylit area are on the automatic daylighting control controlled circuit and lighting outside of the daylit area is not on the controlled circuit. [§131(c)2B&C]

Photosensor has been located properly to minimize unauthorized tampering. [§131(c)2Di]

The photosensor is physically separated from where calibration adjustments are made, or is capable of being calibrated in a manner that the person initiating calibration is remote from the sensor during calibration to avoid influencing calibration accuracy. [§119(f)7]

Sensor located and oriented appropriate to the control type and location of daylit area

Under conditions where no daylight is sensed by the control, the control system increases the light output of each fixture to the design (typically full output) light output.

The controlled fixtures reduce lighting power to no greater than 35 percent of full-load power under fully dimmed and/or stepped conditions. [§131(c)2Dv]

For the continuous and stepped dimming control systems, the lamps do not "flicker" at reduced light output. [§119(f)2]

For the stepped control systems, there is at least one intermediate step between full light output and minimum light output that reduces lighting power to between 70 and 50 percent of full-load power. [§131(c)2Diii]

Stepped dimming and stepped switching control systems have a minimum time delay of 3 minutes or greater before a decrease in electric lighting. [§119(f)3]

For the stepped dimming and stepped switching control systems, the deadband between steps is sufficiently large to prevent cycling between steps for the same daylight illuminance. [§119(f)3]

A "Reference Location" is defined which is served by the controlled lights and receives the least amount of daylight. Usually this is a location that is furthest away from the windows or skylights but is still served by the controlled lighting.

A "Reference Illuminance" is defined at the Reference Location – this is the illuminance from electric lighting when no daylight is available.

For continuous dimming systems; Under partial daylight conditions, the combined daylight and electric lighting illuminance from continuously dimmable fixtures at the Reference Location is no less than the Reference Illuminance and no greater than 150 percent of the Reference Illuminance. [§131(c)2Div &v]

When stepped lighting controls dim or turn off a step, the combined daylight and electric lighting illuminance from stepped dimming or stepped switching fixtures at the Reference Location is no less than the Reference Illuminance and no greater than 150 percent of the Reference Illuminance. [§131(c)2Div &v]

Potential Issues and Cautions

Check fixture circuiting while access to wiring is relatively easy (i.e. while lift is available or before obstructions are installed).

Simulating bright conditions and achieving proper luminance to perform the test can be difficult. Therefore, it is recommended that the test be performed under natural bright light conditions.

For the stepped dimming and switching control systems, it is acceptable to shorten the time delay while performing the tests, but the time delay must be returned to normal operating conditions when the test is complete (at least 3 minutes).

Definition of the daylit areas

The following information on the definitions of the daylit areas are only needed if the designer has not documented well on the plans the daylit areas or if the as built location of windows and skylights do not correspond to the daylit area on the plans. When the plans are incorrectly documenting the daylit area, it is the tester's responsibility to identify the problem and inspect and test the system based upon the as-built configuration of the daylit areas. It is recommended that this is conducted in consultation with the designer. The following definitions are the verbatim language from §131(c) and illustrated below.

Daylight Area, Primary Sidelit is the combined Primary Sidelit Area without double counting overlapping areas. The floor area for each Primary Sidelit Area is directly adjacent to vertical glazing below the ceiling with an area equal to the product of the Sidelit width and the Primary Sidelit depth.

The **Primary Sidelit width** is the width of the window plus, on each side, the smallest of:

- i. 2 feet; or
- ii. The distance to any 5 feet or higher permanent vertical obstruction.

The **Primary Sidelit depth** is the horizontal distance perpendicular to the glazing which is the smaller of:

- i. One window head height; or
- ii. The distance to any 5 feet or higher permanent vertical obstruction.

Daylight Area, Secondary Sidelit is the combined Secondary Sidelit Area without double counting overlapping areas. The floor area for each Secondary

Sidelit Area is directly adjacent to Primary Sidelit Area with an area equal to the product of the Sidelit width and the Secondary Sidelit depth.

The **Secondary Sidelit width** is the width of the window plus, on each side, the smallest of:

- i. 2 feet; or
- ii. The distance to any 5 feet or higher permanent vertical obstruction; or
- iii. The distance to any skylit daylight area

The **Secondary Sidelit depth** is the horizontal distance perpendicular to the glazing which begins from one window head height, and ends at the smaller of:

- i. Two window head heights;
- ii. The distance to any 5 feet or higher permanent vertical obstruction; or
- iii. The distance to any skylit daylight area.

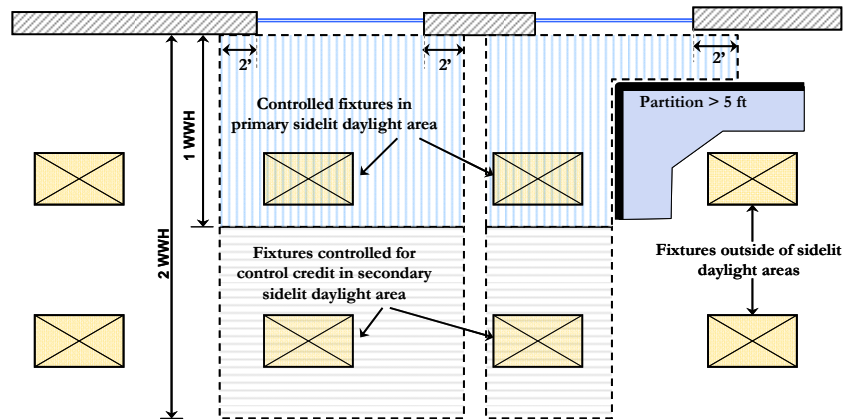


Figure 10-1 – Primary Sidelit Area Plan view

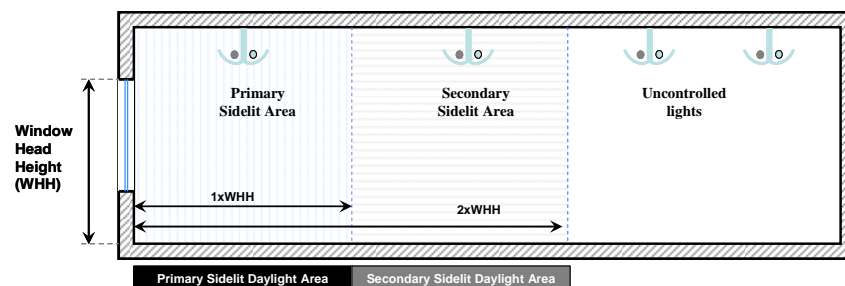


Figure 10-2 – Side view of Primary and Secondary Sidelit Area

Daylight Area, Skylit is the combined daylight area under each skylight without double counting overlapping areas. The daylight area under each skylight is

bounded by the rough opening of the skylight, plus horizontally in each direction the smallest of:

- i. 70 percent of the floor-to-ceiling height; or
- ii. The distance to any primary sidelit area, or the daylight area under rooftop monitors; or
- iii. the distance to any permanent partition or permanent rack which is farther away than 70 percent of the distance between the top of the permanent partition or permanent rack and the ceiling.

In buildings with no partitions, the daylit area under skylights is the footprint of the skylight plus in each direction 70 percent of the ceiling height or halfway to the next skylight or window. This is shown in the next figure

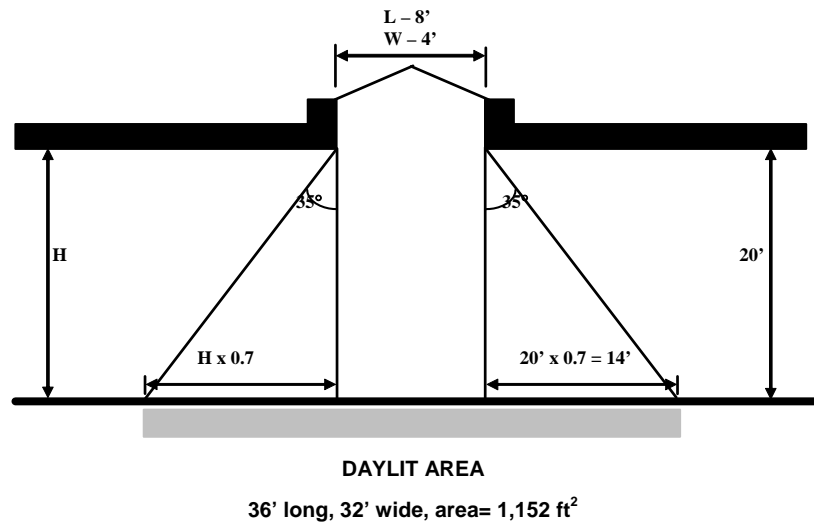


Figure 10-3 – Elevation View of Daylit Area under Skylight (no interior partitions)

If there are permanent partitions or racks below the skylight, the partitions block the full extent of the skylit area. If there is a partition further from the edge of the skylight than 70 percent of the gap between the top of the partition and the ceiling, then the extent of the skylit area stops at the partition. The gap is the ceiling height minus the stack or partition height. The following figure shows this.

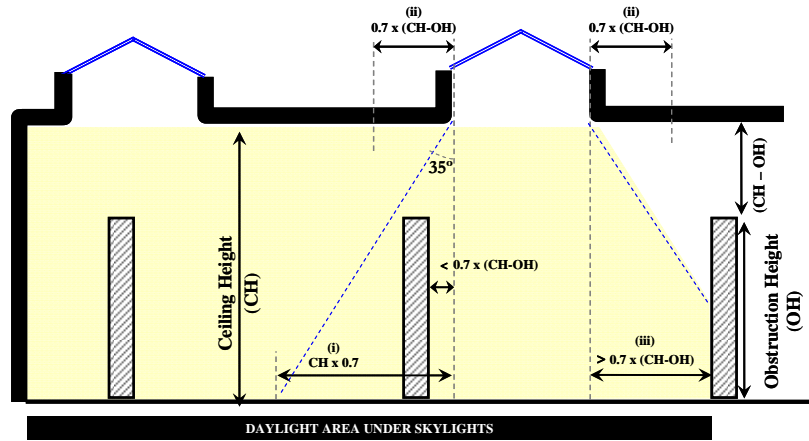


Figure 10-4 – Elevation View of Daylit Area under Skylight (with interior partitions)

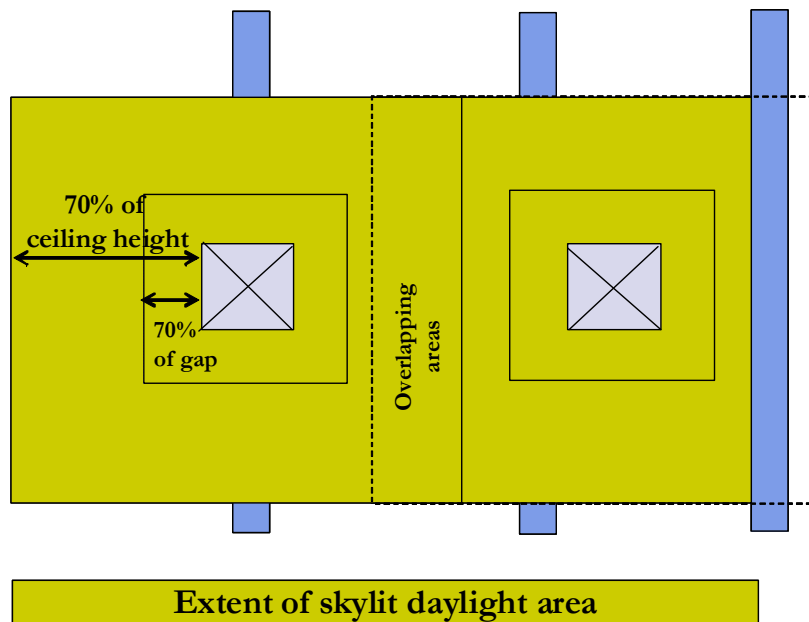


Figure 10-5 – Plan View of Daylit Area under Skylight (with interior partitions)

10.8.2 Test Procedures: NA7.6.1 Automatic Daylighting Control Acceptance, Use Form LTG-3A

Construction Inspection

Purpose of the Test

The purpose of this construction inspection is to ensure that the daylighting controls that are installed in the space meet the location, specification and accessibility requirements per § 119(f); and to ensure that control devices have been certified to the Energy Commission in accordance with the applicable provision in §119.

Criteria for Passing the Test

The system must pass all six key criteria identified in Form LTG-3A Part I:

1. Daylit Zones are clearly marked on plans or drawn on as-built drawings
2. Daylit Zone type and control type is clearly identified on the Form
3. Sensors and controls are appropriate for the daylit area and intended functions, and are located in appropriate locations per §119(f) and §131(c)
4. Sensor and control setpoints are documented and provided to the installer
5. Daylighting controls only control those luminaires that are in the daylit area and luminaires in sidelit daylit areas are controlled separately from luminaires in skylight daylit areas.
6. Daylighting controls have been certified to the Energy Commission in accordance with the applicable provision in §119.

How to Conduct the Test and Fill the Form

Step 1: Daylit Zones Shown on Plans

The building plans are required to have a drawing of the extents of the daylit areas when controls are required or controls are used to obtain lighting control credits.

If the plans do not have the daylit areas indicated for the spaces containing photocontrols, draw the daylit areas on the as-built plans and attach to the acceptance test forms. A copy should be sent to the designer and the building owner.

If more than one type of daylit zones and thus daylighting control systems exist on site, these should be clearly marked on the plans, and also noted on the Form. The Form allows the user to specify up to three (3) systems per Form.

For buildings with several daylighting controls, it is allowable to sample the controls for Acceptance Testing. If this is the case, it should be clearly noted on the forms. A separate sheet should be attached to the Form with names of the other controls and systems that are being represented by the three systems on the Form.

Step 2: System Information

Daylit Zone Type:

There are three types of daylit area:

- 1) The skylit area under skylights,
- 2) The primary sidelit area adjacent to within one window head height of the vertical glazing, and

3) The secondary sidelit area, between the primary sidelit area and two window head heights from the vertical glazing.

The window head height is the distance from the floor to the top of the highest window on the wall section. These areas are defined in §101 “Definitions and Rules of Construction.” This is summarized in the Section titled “*Definition of daylight areas.*”

Controlled Lighting Wattage:

- Note the total wattage of luminaires that are controlled by the given control system. If there are multiple controls systems (A,B,C on the Form), identify controlled wattage separately for each type of control system.
- When the primary sidelit area or skylit area in a room (enclosed space) is greater than 2,500 ft², all general lighting in this daylight area is required to be controlled by an automatic daylighting control.
 - General lighting is defined as lighting that is “designed to provide a substantially uniform level of illumination throughout an area, exclusive of any provision for special visual tasks or decorative effect.” Linear fluorescent troffers and pendants, high and low bay luminaires and other non-directional light sources are considered general lighting.
 - When automatic daylighting controls are required in primary sidelit areas greater than 2,500 ft², these lights must be separately controlled from the secondary sidelit area.
 - Controlling lights in the secondary sidelit area is voluntary or for a control credit.
- The photocontrol must control only those fixtures in the daylight area. A lamp is considered to be in the daylight area if at least ½ of the lamp is in the daylight area. With long pendant fixtures that cross into the daylight area, the lamps that are in the daylight area must be controlled separately from those not in the daylight area.
- Controls for sidelit areas are required to be separate from controls for skylit areas

Note: A higher lighting control credit is available to those designs that control the primary sidelit area separately from the secondary sidelit area. The LTG-1-C form and the plans will indicate whether the control is controlling the lights together or separately.

Note: Identifying which fixtures are controlled by a given sensor or control can be difficult without operating the system. For this reason, it may be better to conduct this portion of the construction inspection in conjunction with the functional performance test.

The controlled fixtures are readily identified by noting which fixtures are turned on and off or are dimming in response to the no daylight and full daylight functional performance tests.

Control Type:

- Identify the type of luminaire control used in each of the control systems identified in the Form. There are three types of controls identified in the Form:
 - Continuous dimming controls are controls that alter the output of lamps in at least 10 steps.
 - Step dimming controls alter the output of lamps in less than 10 steps (usually one or two steps between on and off).
 - Step switching controls turns lamps or groups of lamps on and off without any steps between on and off.
 - Stepped switching controls are able to provide multi-level lighting by having more than one group of lamps being controlled. Partial light output (and partial power consumption) of the stepped switching lighting system is provided by turning some of the lamps on.

Design Footcandles:

Note the design footcandles for general illumination in the daylight zone served by each of the control systems identified in the Form. If the design footcandle is not known for a given control system, clearly identify on the Form that it is unknown.

Step 3: Sensors and Controls

Loop Type and Sensor Location:

- Verify that all photosensors have been properly located. Per §131(c)2D, an individual photosensor must be located so that it is not readily accessible. This placement is intended to make it difficult to tamper with the photosensor. Photocontrols that are part of a wallbox occupancy sensor will not comply.
- The photosensor must be located so that can readily sense daylight entering into the daylight area.
 - Closed loop sensors – sensors that measure both daylight and the controlled electric light shall be located within the area served by the controlled lighting.
 - Open loop sensors – sensors that mostly measure the daylight source shall be outdoors, or near a skylight or window.

Control Adjustment Location:

- Adjustments to the controls must be “readily accessible” to authorized personnel or are in ceilings that are 11 ft or less.
 - Readily accessible means that one can walk up to the control adjustment interface and access it without climbing ladders, moving boxes etc. The control can be in a locked cabinet to

prevent unauthorized access. Controls that can be adjusted via a wireless handheld device would also qualify as being readily accessible.

- Controls that are in ceiling 11 ft or less must be within 2 ft of the ceiling access and the ceiling access must be no more than 11 ft above the floor.

Step 4: Control System Documentation

- Verify that the setpoints, settings and programming on each of the control system device has been documented and provided by the installer.

Step 5: Daylit Zone Circuiting

- Verify that the luminaires in the daylit zone are controlled separately from those outside the daylit zone. Further, verify that the luminaires in daylit areas near windows are circuited separately from the luminaires in daylit areas under skylights.

Step 6: Daylighting Control Device Certification

Verify that installed daylighting controls have been certified to the Energy Commission in accordance with the applicable provisions of §119:

- Automatic Daylighting Control Devices
- Interior Photosensors

Verify that model numbers of all daylighting controls are listed on the Energy Commission database as “Certified Appliances & Control Devices.”

<http://www.energy.ca.gov/appliances/database/>

Functional Performance Testing

There are two separate functional performance tests that are specific to the type of control being tested. The first test is suitable for continuous dimming systems and the second test is for step dimming or step switching controls.

- Continuous dimming controls are controls that alter the output of lamps in at least 10 steps.
- Step dimming controls alter the output of lamps in less than 10 steps (usually one or two steps between on and off).
- Step switching controls turns lamps or groups of lamps on and off without any steps between on and off.
 - Stepped switching controls are able to provide multi-level lighting by having more than one group of lamps being controlled. Partial light output (and partial power consumption) of the stepped switching lighting system is provided by turning some of the lamps on.

The tests for stepped switching and stepped dimming controls are combined as the discrete steps of light output render them sufficiently similar for functional testing.

Note: Many of the steps in these acceptance tests can be conducted while setting up the controls according to manufacturer's instructions. Read these tests prior to conducting equipment set-up and bring the forms along while conducting set-up. This way you can conduct the equipment set-up and perform the acceptance test at the same time.

Sampled functional performance testing of systems smaller than 5,000 ft²

All photocontrols serving more than 5,000 ft² of total daylit area shall undergo functional testing. Photocontrols that are serving 5,000 ft² or less are allowed to be tested on a sampled basis. The sampling rules are as follows:

- For buildings with up to five (5) photocontrols, all photocontrols shall be tested.
- For buildings with more than five (5) photocontrols, sampling may be done on spaces with similar sensors and cardinal orientations of glazing.
- If the first photocontrol in the sample group passes the functional test, the remaining building spaces in the sample group also pass.
- If any photocontrol in the sample group fails, it shall be repaired or replaced as required until it passes the test. An additional photocontrol in the group shall be selected and tested.
- This process shall repeat until all photocontrols have passed the test or the photocontrol tested passes on the first testing.

Zone Illuminated by Controlled Luminaires

The functional performance requirements for both continuous dimming and step (dimming or switching) controls call for "all areas being served by controlled lighting" being between 100 and 150 percent of the night time electric lighting illuminance. Without checking all points in the zone served by controlled lighting, verifying that the requirements are met at a worst case location far away from windows or skylights is sufficient. This location is called the "Reference Location" and is described in the functional performance tests in the next section.

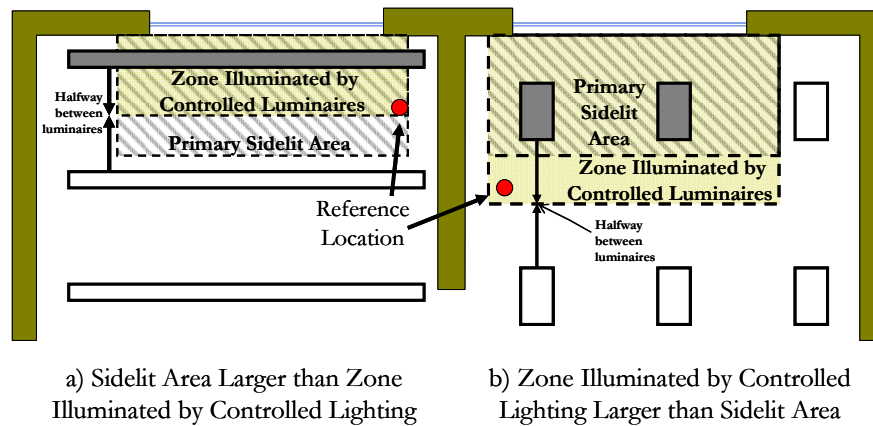


Figure 10-6 – Zone Illuminated by Controlled Luminaires and Reference Location for Measuring Reference Illuminance

Also note that the “zone illuminated by the controlled lighting” is not the same as the sidelit or skylit daylight areas. The sidelit or skylit daylight areas define which luminaires must be controlled. Luminaires in the sidelit or skylit daylight areas must be controlled by automatic daylighting controls, and luminaires outside of these areas must not be controlled by automatic daylighting controls.

The edge of the zone illuminated by the controlled lighting is halfway between the controlled lighting and the uncontrolled lighting. The only situation this is not so, is when the edge of the daylit zone is defined by a partition. The zone illuminated by the controlled luminaires can be smaller than the daylit area when the uncontrolled luminaires are near the edge of the daylit area [see example (a) of Figure 10-6]. Alternatively the zone illuminated by the controlled luminaires can be larger than the daylit area when the controlled luminaires are near the edge of the daylit area [see example (b) of Figure 10-6].

Continuous Dimming Control Systems – Functional Performance Test

Purpose of the Test

This test is for continuous dimming systems with more than 10 steps of light output from the controlled lighting. For instructions on acceptance testing of other systems with less than 10 steps of control, skip this section and proceed to the next section Stepped Switching or Stepped Dimming Control Systems Functional Performance Test.

Criteria for Passing the Test

Key criteria for passing the functional performance test are:

- When there is NO daylight in the space, all controlled luminaires are at full or rated lighting output and power consumption.

- Where there is full daylight in the space (daylight alone provides adequate illumination in space), luminaires in the daylit zone use less than 35 percent of rated power.
- When there is partial daylight (between 60 and 95 percent of the design illuminance) in the space, the luminaires in the daylit zone are dimmed so that the illuminance at the reference location is between the design illuminance and 150 percent of the design illuminance.

The shaded triangle labeled “acceptable range” in Figure 10-7, illustrates the range of total illumination levels that will comply with this requirement.

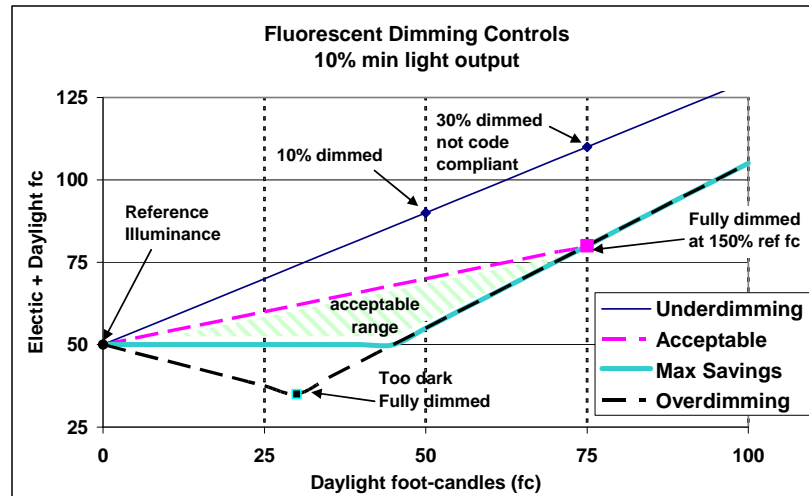


Figure 10-7 – Performance of dimming controls - total light (daylight + electric light) versus daylight

How to Conduct the Test and Fill the Form

Step 1: Identify Reference Location

The Reference Location is the location in zone served by the controlled lighting that is receiving the least amount of daylight.

The Reference Location will be used for light level (illuminance in foot-candles) measurements in subsequent tests. The Reference Location is used in testing the daylighting controls so that it can be assured that all occupants in the zone served by the controlled lighting always have sufficient light.

The Reference Location can be identified using either the illuminance method or the distance method.

Illuminance Method:

- Turn OFF controlled lighting and measure daylight illuminances within zone illuminated by controlled luminaires. Note that zone illuminated by controlled luminaires is not necessarily the same as the daylit area. See the Section above with the heading “Zone Illuminated by Controlled Luminaires.”

- Identify the Reference Location; this is the location with lowest daylight illuminance in the zone illuminated by controlled luminaires.
- Turn controlled lights back ON.

Distance Method:

- Identify the Reference Location; this is the location within the zone illuminated by controlled luminaires that is furthest way from daylight sources. Note that zone illuminated by controlled luminaires is not necessarily the same as the daylight area. See the note above with the heading “*Zone Illuminated by Controlled Luminaires.*”

Step 2: No Daylight Test

The purpose of the no daylight test is to provide a baseline light level, the Reference Illuminance, against which the test professional will be comparing the performance of the system during daylight conditions. This test is also verifying that the control is providing adequate light at night.

When conducting this test, the other lights in the space should be turned off. Simulate or provide conditions without daylight. This condition can be provided by any of the applicable methods:

- Conducting this part of the test at night, or
- Leave a logging light meter at the Reference Location(s) overnight. The logger should be collecting data on an interval no longer than 1 minute per reading, taking reading on even shorter intervals is recommended.
- Closing blinds or covering fenestration so that very little daylight enters the zone you are testing, or
- Very little daylight is less than 1 fc for warehouses and less than 5 fc for all other occupancies.
- For open loop systems only, one may cover the photosensor to simulate no daylight conditions. Covering the sensor is not allowed for closed loop controls as we want to assure that the control will work correctly at night as well during the day. We will want to assure that the light output is above 70 percent of the rated light output or within 20 percent of the design illuminance.

Reference Illuminance:

Document the Reference Illuminance (fc) – the horizontal electric lighting illuminance (footcandles) at the Reference Location identified in Step 1.

- This measurement is taken by an illuminance sensor (light meter) 30 inches above floor level. The sensor should be facing upwards. Mounting the light meter on a tripod is recommended so that consistent measurements are taken. Try not to shade the meter with your body while taking measurements.

-
- When it is not possible to exclude daylight from the space during this test, the Reference Illuminance can be calculated by subtracting the daylight illuminance from the combined illuminance (footcandles) of the electric lighting and daylight. The daylight illuminance is measured by turning off the controlled lights.

Power Measurement (Optional):

If a current or power measurement is going to be used in Step 3 to show power reduction under fully dimmed conditions, collect full load current or power.

- This is not normally necessary for systems with dimming fluorescent ballasts. It is easier just to compare electric lighting illuminance. For more details see Step 3 “Full Daylight Test.”

Full load rating or measurement

The full load rating can be obtained a number of ways:

- One may also choose to manipulate the calibration adjustments (remember to write down the setting first before changing them) to obtain full light output from the controlled lighting. This might require turning the setpoint very low and turning the high limit very high. Discuss your approach with the control manufacturer with their recommendations to get full light output. If the photosensor is accessible, covering the photosensor is a way to assure full light output.
- If you cannot eliminate all daylight from the area or other electric light from other luminaires. Turn the controlled lighting on and off and the difference in light level will be the contribution of the controlled lighting.
- If one is measuring power or amps, the rated amps can be directly measured under this condition. First verify that only the controlled lights in the daylit area are being measured. You may want to disconnect and re-energize this circuit to assure you are measuring what you intend.
- The rated amps or power from the manufacturer’s cut-sheet is also sufficient.

Sufficient Illumination Test

Verify that the controlled lighting is providing sufficient illumination under no daylight conditions. The system is deemed to be providing sufficient illumination if any of the following conditions are true:

- The No Daylight Reference Illuminance (fc) is at least 70 percent of the Full Load Illuminance (fc).
- Measured Amps or Watts are at least 70 percent of the Full Load Amps or Watts.
- Measured Amps or Watts are at least 70 percent of the Full Load Amps or watts from the Manufacturer’s cut-sheets.

- The No Daylight Reference Illuminance (fc) is within 20 percent of the design illuminance as documented on the plans.

Step 3: Full daylight test.

Simulate or provide bright conditions so that the illuminance (fc) from daylight only at the Reference Location identified in Step 1 is greater than 150 percent of the Reference Illuminance (fc) measured at this location during the no daylight test documented in Step 2.

- Simulating a bright condition can be accomplished by opening all shading devices to allow natural daylight into the space
- If natural conditions are not adequate at the time of the test, shine a bright flashlight or other light source onto the photosensor.
- Temporarily change the setpoint to a very low value for the duration of this test. Then return the setpoint to its normal setting.

Verify and document the following:

Lighting power reduction is at least 65 percent under fully dimmed conditions.

Lighting power reduction can be determined as follows:

- Dimming fluorescent lighting is deemed to reduce power by 65 percent when the controlled electric light output is reduced by 75 percent
- Dimming metal halide is deemed to have reduced power by 44 percent when light output is reduced by 75 percent.
- One method of attaining the 65 percent power reduction with dimming metal halide systems is to turn off half of the luminaires and dim the other half.
- The power reduction in higher performing dimming ballasts can be estimated from lighting output reductions if it is accompanied with a manufacturer's ballast cut sheets containing a ballast input power vs. percent light output curve or table.
- Power reduction can be directly measured using either a power meter or an ammeter. The percent reduction in current will be a sufficient representation of the percent reduction in power.
- The system lighting power reduction is given by the following relations:

$\text{Reduction} = \text{Fraction of lights turned off} + \text{Fraction of lights dimmed} \times \text{power reduction of the dimmed lamps}$

Where,

The power reduction of dimmed lamps =

$(\text{Rated power} - \text{dimmed power}) / \text{rated power}$

An example of this equation is given below for where a metal halide dimming system dims half of the lamps and the other half of the lamps are automatically switched off. The System Power Reduction, SPR is:

$$\text{SPR} = 0.5 + (0.5 \times 0.44) = 0.72 \text{ or } 72 \text{ percent}$$

This is above the 65 percent threshold.

Verify that only luminaires in appropriate daylit zone are affected by daylight control.

- Sidelit zones have to be separately controlled from skylit zones.
- If the primary sidelit area is greater than 2,500 ft², the primary sidelit area shall be separately controlled from both skylit areas and secondary sidelit areas.
- For smaller sidelit areas, if the designer has taken the higher lighting control credit for separately controlling the primary sidelit area from the secondary sidelit area, the two areas have to be separately controlled.
- The daylighting control shall not control fixtures outside of daylit areas.

Verify that light output is stable with no discernable flicker.

The intent of this requirement is to ensure the lights do not flicker because occupants may override the system if light flicker is an annoyance. Flicker refers to a rapid fluctuation in light output that can be detected by the human eye.

Step 4: Partial daylight test.

Simulate or provide bright conditions where illuminance (fc) from daylight only at the Reference Location is between 60 and 95 percent of Reference Illuminance (fc) documented in Step 2. These partial daylight illuminance conditions can be achieved by:

- Scheduling the test so that daylight conditions are within this fairly broad range of illuminances.
- Adjusting blinds and louvers

Verify and document the following:

- Measured combined illuminance of daylight and controlled electric lighting (fc) at the Reference Location
- Verify this measured illuminance is no less than the Reference Illuminance documented in Step 2, and
- Verify this measured illuminance is no greater than 150 percent of the Reference Illuminance (fc) documented in Step 2

This test assures that the control does not over-dim and leave people with not enough light in the Reference Location of the zone served by the controlled lights. This also makes sure that the control does not under-dim and not save enough energy. By setting the upper bound of illuminance to 150 percent of the Reference Illuminance, this leaves plenty of room for non-optimal configurations and for adaptation compensation.

Note: Adaptation compensation is a control strategy that accounts for people needing less light at night. When someone walks into a store late at night from a parking lot with light levels at 1 fc they may not need or want light at 50 fc. Thus a store may decide to have higher light levels during the day than at night. This protocol would allow daytime light levels that are 50 percent higher than the night time light levels.

Stepped Switching or Stepped Dimming Control Systems Functional Performance Test

Purpose of the Test

This functional performance test is for systems that have no more than 10 discrete steps of control of light output. For instructions on how to test systems with more than 10 steps of control including those systems where the dimming appears to continuous proceed to the previous section: Continuous Dimming Control Systems - Functional Performance Test.

If the control has three steps of control or less, conduct the following tests for all steps of control. If the control has more than three steps of control, testing three steps of control is sufficient for showing compliance.

If these tests are to be conducted manually (spot measurements) it is recommended to test the system with the time delay minimized or otherwise overridden so the test can be conducted more quickly.

These tests can also be conducted with a logging (recording) light meter. In this case, the time delay should be left on so the recorded data also shows the results of the time delay. In the logging method, one would print out a plot of the day's illuminance at the Reference Location and annotate the plot showing where each stage of lighting had shut off and how the light level just after shutting off for each stage is between the Reference Illuminance and 150 percent of the Reference Illuminance.

Criteria for Passing the Test

Key criteria for passing the functional performance test are:

- When there is NO daylight in the space, all controlled luminaires are at full or rated lighting output and power consumption.
- Where there is full daylight in the space (daylight alone provides adequate illumination in space), luminaires in the daylit zone use less than 35 percent of rated power.
- When there is some daylight in the space, the luminaires in the daylit zone are switched or dimmed appropriately.
- If the control has three steps of control or less all steps of control are tested. If the control has more than three steps of control, testing three steps of control is sufficient for showing compliance.
- There is a time delay of at least 3 minutes between when daylight changes from little daylight to full daylight and the luminaire power consumption reduces through dimming.

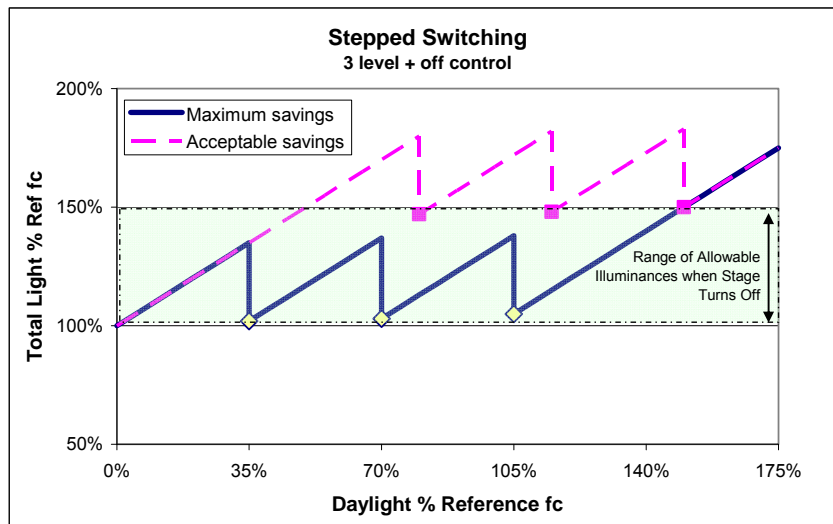


Figure 10-8 – Performance of compliant switching controls - total light (daylight + electric light) versus daylight

As shown in Figure 10-8, the acceptance tests will confirm that the total illuminance at the reference location is between 100 and 150 percent of the reference illuminance. The highlighted points on the plots (squares and diamonds) indicate the daylit and total light levels at the reference location just after the lights on each stage of control have turned off or dimmed.

The plot of the “Maximum savings” control illustrates how this control maximizes the possible lighting energy savings without under-lighting the space. Systems with lower control setpoints than the “Maximum savings” control would not be compliant as the control would under-light the space during certain times of the day and would likely lead to the control being disabled.

The plot of the “Acceptable savings” control shows how this control maintains light levels above the reference illuminance for all daylit hours but still saves enough energy to be minimally compliant. Systems with higher setpoints than those of the “Acceptable savings” control would not be compliant.

How to Conduct the Test and Fill the Form

Step 1: Identify Reference Location

The Reference Location is the location in zone served by the controlled lighting that is receiving the least amount of daylight. The Reference Location will be used for light level (illuminance in foot-candles) measurements in subsequent tests. The Reference Location is used in testing the daylighting controls so that it can be assured that all occupants in the zone served by the controlled lighting always have sufficient light.

If lighting controls are staged so that one stage is closer to the daylight source, identify a minimum daylighting location for each stage of control.

If lighting controls are NOT staged based on distance to the daylight source, select a single minimum daylighting location representing all stages of the control. This minimum daylighting location for each stage of control is designated as the

Reference Location for that stage of control and will be used for illuminance measurements in subsequent tests.

The Reference Location can be identified using either the illuminance method or the distance method.

Illuminance Method

- Turn OFF controlled lighting and measure daylight illuminances within zone illuminated by controlled luminaires
- Identify the Reference Location; this is the location with lowest daylight illuminance in the zone illuminated by controlled luminaires.
- Turn controlled lights back ON.

Distance Method

- Identify the Reference Location; this is the location within the zone illuminated by controlled luminaires that is furthest way from daylight sources.

Step 2: No Daylight Test

Simulate or provide conditions without daylight for a stepped switching or stepped dimming control system. This condition can be provided by any of the applicable methods:

- Conducting this part of the test at night, or
- Leave a logging light meter at the Reference Location(s) overnight, (the logger should be collecting data on an interval no longer than 1 minute per reading, taking reading on even shorter intervals is recommended) or,
- Closing blinds or covering fenestration so that very little daylight enters the zone you are testing, (very little daylight is defined as less than 1 fc for warehouses and less than 5 fc for all other occupancies), or
- Cover the photosensor

If the control is manually adjusted (not self commissioning), make note of the time delay and override time delay or set time delay to minimum setting. This condition shall be in effect through Step 4.

When conducting this test, the other lights in the space should be turned off.

Verify and document the following:

- Automatic daylight control system turns ON all stages of controlled lights
- Document the Reference Illuminance (fc) – the horizontal electric lighting illuminance (footcandles) at the Reference Location identified in Step 1.
- This measurement is taken by an illuminance sensor (light meter) 30 inches above floor level. The sensor should be facing upwards. Mounting

the light meter on a tripod is recommended so that consistent measurements are taken. Try not to shade the meter with your body while taking measurements.

- When it is not possible to exclude daylight from the space during this test, the Reference Illuminance can be calculated by subtracting the daylight illuminance from the combined illuminance (footcandles) of the electric lighting and daylight. The daylight illuminance is measured by turning off all nearby lights including the controlled lights.
- For step dimming controls, calculate power consumption using the manufacturer provided cut-sheet information or measure the power consumption.
- (Optional) If a current or power measurement is going to be used in Step 3 to show power reduction under full daylight conditions, collect full load current or power. *Note:* no power measurements are needed for step switching systems.

Step 3: Full Daylight Test

Simulate or provide bright conditions so that the illuminance (fc) from daylight only at all of the Reference Location(s) identified in Step 1 is greater than 150 percent of the corresponding Reference Illuminance(s) documented in Step 2.

- Simulating a bright condition can be accomplished by opening all shading devices to allow natural daylight into the space, or
- If natural conditions are not adequate at the time of the test, shine a bright flashlight or other light source onto the photosensor, or
- Temporarily change the setpoint to a very low value for the duration of this test then return the setpoint to its normal settings.

Verify and document the following:

- Lighting power reduction of controlled luminaires is at least 65 percent of rated power consumption. Methods of doing this include:
- For switching systems at least 2/3s of the lamps are turned off.

Note: for switching systems, power measurement is unnecessary. The fraction of power reduction is easily estimated without taking power measurements. The fraction of power reduction is calculated by counting the number of lamps that are switched off versus the total number of lamps providing general lighting in the daylit area.
- For stepped dimming systems, either calculates the fraction of rated power at the dimming stage from the ballast manufacturer's cut sheet or from power measurements taken during the No daylight and full daylight tests.
 - If using the manufacturer's cut-sheet, wattage at full output and dimmed amounts are given. A copy of this cut-sheet must be attached to the acceptance testing form. Count the number of dimmed fixtures and those fully turned off to calculate reduced

power operation. If calculated power is 35 percent or less of the power calculated in Step 2, this meets the criteria.

- If using measured power or current draw of the controlled fixtures. If measured power or current draw is 35 percent or less the value from Step 2, the criteria is met.
- Only luminaires in daylit zones (toplit zone, primary sidelit zone and secondary sidelit zone) are affected by daylight control.
- Automatic daylight control system reduces the amount of light delivered to the space relatively uniformly as per §131(b).
 - All lights are dimmed
 - Alternating lamps, alternative fixtures or alternating rows of fixtures are turned off.
 - Uniformity is improved if fixtures closest to the daylit source are controlled before those further away.
 - Stepped dimming control system provides reduced flicker over the full range of dimming.

Step 4: Partial daylight test

For each stage of control that is tested in this step, the control stages with lower setpoints than the stage tested are left ON and those stages of control with higher setpoints are dimmed or controlled off. This step is repeated for up to three stages of control between full on and full dimmed or full off condition.

One of the stages selected for testing should reduce power draw between 30 and 50 percent of system rated power (for switching systems a stage that turns off between a third and a half of the lamps). That test will help confirm that the system can reduce power between 30 and 50 percent.

Simulate or provide moderately bright conditions so that each control stage turns on and off or dims. Methods to do this include:

- **Adjusting blinds or shades.** Note that the time delay needs to be disabled to use this method. Slowly increase the daylight illuminance until a stage of lighting turns off. Make note of the total combined and electric lighting illuminance at the Reference Location just after the stage of lights turned off. Continue increasing daylight illuminance by opening blinds or shades for at least two more stages of control
- **Light logging.** Leave a logging light meter at the Reference Location(s) for one day with a bright afternoon. The logger should be collecting data on an interval no longer than 1 minute per reading, taking reading on even shorter intervals is recommended.
- **Open loop ratio method.** If the system is open loop (the light sensor senses mainly daylight) the amount of daylight in the space is proportional to the amount measured at the open loop sensor. Adjust setpoint until control turns lights off or are dimmed. Make note of daylight illuminance at the reference location and control setpoint or sensor illuminance display.

-
- If the sensor measures 300 fc while there is 30 fc of daylight at the Reference Location, the ratio of Sensed fc to fc at Reference Location is 10 to 1. If the needed daylight illuminance is 50 fc a setpoint of 500 sensed fc is deemed to provide control at 50 fc.

Verify and document the following for each tested control stage:

Note: The tests do not need to be performed for more than three stages of control.

- The total daylight and electric lighting illuminance level measured at its Reference Location just after the stage of control dims or shuts off the stage of lighting.
- The total measured illumination shall be no less than the than the Reference Illuminance measured at this location during the No Daylight test documented in Step 2.
- The total measured illumination shall be no greater than 150 percent of the Reference Illuminance.
- The control stage shall not cycle on and off or cycle between dim and undimmed while daylight illuminance remains constant.
 - *Note:* Cycling is prevented by having a deadband that is sufficiently large. The deadband or the difference between the setpoint for turning the control stage ON and the setpoint for turning that control stage OFF. The deadband must be greater than the sensor measurement of the controlled lighting to prevent cycling of lamps on and off.
 - Note that for manual testing of the control that the time delay is overridden so it is quickly apparent if the deadband is set appropriately.
- If the deadband is too small, the system will cycle. This will be an annoyance and may lead to the system being disabled by irritated occupants.
- If the deadband is set too large, the system will not save as much energy as it could.
- To manually set a deadband adjust the daylight level or the setpoint so that the setpoint matches the daylight illuminance. Reduce the deadband until the system cycles and then increase the deadband until the system stops cycling.

Step 5: Verify time delay

- Verify that time delay automatically resets to normal mode within 60 minutes of being over ridden.
- Set normal mode time delay to at least 3 minutes.

- Confirm that there is a time delay of at least 3 minutes between the time when illuminance exceeds the setpoint for a given dimming stage and when the control dims or switches off the controlled lights.
 - *Note:* One can force a change of state and by dropping the setpoint substantially and timing how long it takes for the control stage to switch off or dim.

10.8.3 NA7.6.2 Occupancy Sensor Acceptance

At-A-Glance

NA7.6.2 Occupancy Sensor Acceptance

Use Form LTG-2A

Purpose of the Test

The purpose of the test is to ensure that occupancy sensors are located, adjusted, and wired properly to achieve the desired lighting control. There are three basic technologies utilized in most occupancy sensors: 1) infrared; 2) ultrasonic; and 3) a combination of infrared and ultrasonic.

Benefits of the Test

Occupancy sensors are used to automatically turn lights ON immediately when a space is occupied, and automatically turn them OFF when the space is vacated after a pre-set time delay. Some sensors are configured so the user must manually switch the lights ON but the sensor will automatically switch the lights OFF (manual on controls). Automated lighting controls prevent energy waste from unnecessarily lighting an unoccupied space.

Instrumentation

This test verifies the functionality of installed occupancy sensors visually and does not require special instrumentation.

Test Conditions

Occupancy sensors are installed properly, and located in places that avoid obstructions and minimize false signals.

All luminaires are wired and powered.

During the test, the space remains unoccupied.

Document the initial conditions before overrides or manipulation of the BAS. All systems must be returned to normal at the end of the test.

Estimated Time to Complete

Construction Inspection: 0.25 to 0.5 hours (depending on visual and audible inspection requirements)

Equipment Test: 0.5 to 1 hours (depending on necessity to adjust time delay or mask sensor to prevent false triggers)

Acceptance Criteria

Standard occupancy sensor responds to “typical” occupant movement to turn the lights ON immediately.

Manual ON occupancy sensor requires occupant to switch lighting on.

Multi-level occupant sensors meet uniformity requirements; the first stage activates between 30-70 percent of the lighting power; after that event the occupant has the ability to manually activate the alternate set of lights, activate 100 percent of the lighting, deactivate all of the lights.

Ultrasonic occupancy sensors do not emit audible sound.

Lights controlled by the occupancy sensor turn OFF when the preset time delay is met.

The maximum time delay is not greater than 30 minutes.

Occupancy sensor does not trigger a false ON or OFF.

Status indicator or annunciator operates correctly.

Potential Issues and Cautions

It is imperative that the test be performed during a time when the tester can have full control over the occupancy of the space.

The time delay can be adjusted to minimize test time, but the time delay setting must be reset upon completion of the test (not to exceed 30 minutes).

Plan sensor location to avoid detection of significant air movement from an HVAC diffuser or other source, which can cause the sensor to turn the lights ON (this is most critical with ultrasonic sensors).

Avoid detection of motion in adjacent areas and unwanted triggers by adjusting coverage pattern intensity or masking the sensor with an opaque material.

Educating the owner about furniture and partition placement in the spaces can avoid future problems with infrared sensor performance (which rely on “line-of-sight” coverage).

10.8.4 Test Procedure: NA7.6.2 Occupancy Sensor Acceptance, Use form LTG-2A

Purpose (Intent) of the Test

The purpose of the test is to ensure that an occupancy sensor is located, adjusted, and wired properly to achieve the desired lighting control. Occupancy sensors are used to automatically turn lights on and keeps them on when a space is occupied, and turn them off automatically when the space is unoccupied after a reasonable time delay. The time delay, typically adjustable, will prevent lights from short cycling ON and OFF as spaces are occupied and unoccupied frequently. There are three basic technologies utilized in most occupancy sensors: 1) infrared; 2) ultrasonic; and 3) a combination of infrared and passive sonic detection.

Construction Inspection

Occupancy sensor has been located to minimize false signals (both false ON and OFF). False signals can include, but is not limited to:

- Detection of motion in adjacent areas outside of desired control area. Coverage pattern intensity adjustment or sensor masking may be needed to prevent detection outside of the desired control area. Occupancy sensors are positioned so they “look” across the doorway not through it.
- Detection of heavy air flow. This can be prevented by locating a sensor more than 6 ft away from an HVAC diffuser or other source of air movement (this is most critical with ultrasonic sensors). The sensitivity of the sensor can also be adjusted to minimize false signals due to air movement.
- Occupancy sensor does not encounter obstructions that could adversely affect desired performance, including but not limited to: walls, partitions (temporary or permanent), office furnishings (desks, book cases, filing cabinets, plants), or doors. Note that obstruction limitations are more critical when using infrared occupancy sensors since this technology relies on “line-of-sight” coverage. Ultrasonic sensors are less susceptible to obstructions.
- Ultrasonic sensors do not emit audible sound. As the name implies, ultrasonic sensors emit ultrasonic sound waves at frequencies that should be imperceptible to the human ear. Ensure the sensor does not emit any sounds that ARE audible to the human ear at typical occupant location.
- Regular noise in the room (such as HVAC noise) does not result in passive sonic detection keeping lights on. The sensitivity of the sensor can also be adjusted to minimize false signals due to regularly occurring noises.

Ensure that occupant sensors have been certified to the Energy Commission in accordance with the applicable provision in §119. Verify that model numbers of all occupant sensors are listed on the Energy Commission database as “Certified Appliances & Control Devices.”

<http://www.energy.ca.gov/appliances/database/>

Functional Testing**Step 1: Simulate an unoccupied condition.**

Ensure the space being tested remains unoccupied during the test and wait for the lights to turn off (sensor delay time can be adjusted to shorten test time).

Verify and Document

Lights controlled by the occupancy sensor turn off when the time delay is met. If the time delay was not adjusted prior to the test, ensure the maximum delay was not greater than 30 minutes. If the time delay was adjusted to minimize test time, ensure the sensor time delay setting does not exceed 30 minutes.

Occupancy sensor does not trigger a false ON. Ensure that any movement outside the desired control zone does not activate the lights. Examples include:

- Walking past an open door of an enclosed office
- Walking in an adjacent zone close to the control zone
- Movement other than occupants (i.e. air flow from HVAC system or furnishing movement due to external forces)

Step 2: For a representative sample of building spaces, simulate an occupied condition. Enter the test space.

Verify and Document

Ensure the lights in the control zone turn on immediately. Note that some applications may use an occupancy sensor in conjunction with an automatic control switch, which allows the occupant to manually turn ON/OFF the lights or allow them to automatically turn off when the space is unoccupied (automatic OFF and manual ON control strategy). In this case, activation of the control switch should enable the lights and they should stay illuminated while the space is occupied. The occupancy sensors that are required to have “manual on” capability are identified on the Lighting Control Worksheet.

Signal sensitivity is adequate to achieve the desired control. Ensure occupancy sensor responds to “typical” occupant movement to trigger lights back on. This may require remaining in the space throughout the time delay period to ensure the occupancy sensor continues to recognize the space is occupied. “Typical” movement pertains to the activities one may expect for the space being served, for example: light desk work; casual walking; athletic movement (i.e. fitness rooms); sitting at rest (i.e. lunch/break room).

Status indicator or annunciator operates correctly. Most occupancy sensors have an LED that will illuminate (typically flash) when motion is detected, where others may emit an audible sound.

Additionally, if the occupant sensor is a multi-level occupant sensor used to qualify for a Power Adjustment Factor in accordance with §146(a)2D, ensure that all of the following occurs:

- The first stage activates between 30-70 percent of the lights either manually or automatically. This may be accomplished with a switching or dimming lighting system.
- A reasonably uniform level of illuminance is achieved by dimming of all lamps or luminaires; or by switching alternate lamps in luminaires, alternate luminaires, or alternate rows of luminaires.
- After the first stage occurs, manual switches have been provided to activate the alternate set of lights, activate 100 percent of the lighting power, and deactivate all of the lights.

Step 3: Return system back to normal operating condition.

Ensure all schedules, setpoints, operating conditions, and control parameters (especially time delays) are placed back at their initial conditions.

10.8.5 NA7.6.3 Manual Daylighting Control Acceptance

At-A-Glance**NA7.6.3 Manual Daylighting Control Acceptance****Use Form LTG-2A****Purpose of the Test**

The purpose of this test is to ensure that spaces exempt from the automatic daylighting control requirements (refer to §131(c)2) are capable of achieving reduced lighting levels manually under bright conditions. Manual lighting controls can include, but are not limited to, switches and dimmers.

Benefits of the Test

Reducing artificial light output when adequate daylight is available improves overall light quality and reduces energy usage.

Instrumentation

To perform the test, it will be necessary to validate overall power reduction. The instrumentation needed to perform the task may include, but is not limited to:

- Light meter
- Hand-held amperage and voltage meter
- Power meter
- Dimming ballast manufacturer's light versus power curve

Test Conditions

The luminaires within each space are wired to manual switches and/or dimmers.

All luminaires are wired and powered.

Estimated Time to Complete

Construction Inspection: 0.25 to 0.5 hours (depending on access to necessary construction documentation – i.e. electrical drawings, material cut sheets, etc.)

Equipment Test: 0.5 to 2 hours (depending on method employed for verifying required power reduction)

Acceptance Criteria

Manual switching or dimming achieves a lighting power reduction of at least 50 percent within the control zone.

The amount of light delivered to the control zone is uniformly reduced.

For the dimming controls, the lamps do not “flicker” at a reduced light output condition.

Potential Issues and Cautions

Verifying required power reduction can be difficult when using dimmers. One method is to measure power (either directly or by calculating power using measured volts and amps) at maximum and minimum dimmer positions. Another method would be to measure light level at maximum and minimum dimmer positions and compare these values with ballast manufacturer's published data on input power vs. percent light output.

Uniform reduction in light level is subjective when lights are controlled by switches. Switching two of four lamps in a 4-lamp luminaire or having the center lamp and two outside lamps in a 3-lamp luminaire on separate switches are reasonable examples of "uniform" lighting.

10.8.6 Test Procedures: NA7.6.3 Manual Daylighting Control Acceptance, Use form LTG-2A

Purpose (Intent) of the Test

When the total primary sidelit daylight area or total skylit daylight area in an enclosed space is greater than 250 ft² and has adequate daylight, controls must be installed which are capable of reducing the amount of electric lighting in the daylit areas. The purpose of this test is to ensure that spaces not required to have automatic daylighting control are capable of achieving reduced lighting levels manually. Manual lighting control can include, but is not limited to, switches and dimmers. The lights must be controlled separately from lights outside the daylit area. Definitions and figures describing the primary sidelit daylight area and skylit daylight area are in Section 10.8.1 of this chapter.

Construction Inspection

If dimming ballasts are specified for light fixtures within the daylit area, ensure they meet all Standards requirements, including "reduced flicker operation" for manual dimming control systems. Flicker refers to a rapid fluctuation in light output that can be detected by the human eye.

Functional Testing

Step 1: Perform manual switching control. Ensure the lights within each space are controlled correctly. Acceptable control includes, but is not limited to, toggle switches or dimmers.

Verify and Document

Manual switching or dimming achieves a lighting power reduction of at least 50 percent within the daylit area. This can include a power reduction of 100 percent as well. For toggle switch controls, this implies that at least 50 percent of the lamps (not necessarily fixtures) serving the control zone should be connected to common switches and can be turned off. It is implied that 50 percent power reduction is achieved if 50 percent or more of the lamps have been turned off (i.e. two or more lamps in a 4-lamp fixture). For dimmers, it is more likely that all of the

fixtures and lamps within the control zone will be controlled simultaneously.

Verifying power reduction using dimmer control can include, but is not limited to:

- Measure maximum light output (minimum dimmer position) and minimum light output (maximum dimmer position) to calculate a percent output value and compare this value with manufacturer's specified power input at that percent light output. If lights are hard to reach, turn off lights to measure daylight footcandles and subtract daylight footcandles from maximum and minimum measurements of lights at full power and lights fully dimmed. Most ballast manufacturers will provide a curve illustrating the ballast input power vs. percent light output. If input power at maximum dimmer position achieves a 50 percent power reduction over minimum dimmer position, the system passes.
- Measure input power to the fixture at both full and minimum dimmer positions. The difference between the two measurements determines power reduction (it is acceptable to measure input amps and voltage and calculate power).

The amount of light delivered to the control zone is uniformly reduced. The intent of this requirement is to prevent severe contrasts in illumination within the space because occupants may override the system if uneven light distribution is an annoyance. For switch control, examples of uniform illuminance include: two of four lamps in a fixture are turned off; center lamp or two outside lamps in 3-lamp fixtures are turned off; or lamps closest to the daylight source turn off completely but those further away remain operating. As stated above, dimmer applications will typically control all of the lights in the control zone uniformly, but variation may occur depending on how the fixtures are actually wired.

Step 2: Return system back to normal operating condition.

Ensure all schedules, setpoints, operating conditions, and control parameters are placed back at their initial conditions.

10.8.7 NA7.6.4 Automatic Time Switch Control Acceptance

At-A-Glance

NA7.6.4 Automatic Time Switch Control Acceptance

Use Form LTG-2A

Purpose of the Test

The purpose of this test is to ensure that all non-exempt lights, per §131(d)1, are automatically turned off at a predetermined time and individual lighting circuits can be manually enabled, if necessary, during scheduled OFF periods (i.e., a lighting "sweep").

Benefits of the Test

An automated control to turn off lighting during typically unoccupied periods of time prevents energy waste.

Instrumentation
This test verifies the functionality of installed automatic time switch controls visually and does not require special instrumentation.
Test Conditions
<p>All luminaires and override switches controlled by the time switch control system must be wired and powered.</p> <p>Lighting control system must be installed and ready for system operation, including completion of all start-up procedures, per manufacturer's recommendations.</p> <p>Preferably, the space is unoccupied during the test to prevent conflicts with other trades.</p> <p>Document the initial conditions before overrides or manipulation of the BAS. All systems must be returned to normal at the end of the test.</p>
Estimated Time to Complete
<p>Construction Inspection: 0.5 to 2 hours (depending on familiarity with lighting control programming language)</p> <p>Equipment Test: 2 to 6 hours (depending on familiarity with lighting control programming language, number of lighting circuits and override switches to be tested, and programmed time delay between ON and OFF signals)</p>
Acceptance Criteria
<p>Automatic time switch controls are programmed with acceptable weekday, weekend, and holiday schedules, per building occupancy profile.</p> <p>The correct date and time are properly set in the lighting controller.</p> <p>Have program backup capabilities that prevent the loss of the device's schedules for at least 7 days, and the device's time and date setting for at least 72 hours is power is interrupted</p> <p>All lights can be turned ON manually or turn ON automatically during the occupied time schedule.</p> <p>All lights turn OFF at the preprogrammed, scheduled times.</p> <p>The manual override switch is functional and turns associated lights ON when activated.</p> <p>Override time limit is no more than 2 hours, except for spaces exempt per §131(d)2.D.</p> <p>Enunciator warning the occupants that the lights are about to turn OFF functions correctly.</p> <p>Ensure that occupant sensors have been certified to the Energy Commission in accordance with the applicable provision in §119. Verify that model numbers of all occupant sensors are listed on the Energy Commission database as "Certified Appliances & Control Devices."</p> <p>http://www.energy.ca.gov/appliances/database/</p>
Potential Issues and Cautions
<p>The manual override time limit can be adjusted to minimize test time, but the time limit setting must be reset upon completion of the test (not to exceed 2 hours).</p> <p>It is preferable to perform the test when the spaces are unoccupied. Turning the lights OFF when other occupants are present can cause problems and unsafe working conditions.</p>

Purpose (Intent) of the Test

The purpose of this test is to ensure that all non-exempt lights per §131(a) are automatically turned off at a predetermined time and individual lighting circuits can be manually enabled, if necessary, during scheduled OFF periods. The most common term for this control strategy is a lighting “sweep”.

Construction Inspection

- Automatic time switch control is programmed with acceptable weekday, weekend, and holiday schedules. Non-exempt lights should be scheduled OFF a reasonable time after the space is typically unoccupied (i.e., 1 or 2 hours after most people have already left the space).
- Verify schedule and other programming parameter documentation was provided to the owner. This information will be used to verify system operation. The documentation should include weekday, weekend, and holiday schedules as well as sweep frequency and/or override time period. Sweep frequency or override time period refers to how often the OFF signal is sent through the system and commands the lights OFF again.
- Verify correct date and time is properly set in the time switch. Lights will not be controlled correctly if the programmed date and time do not match actual values.
- Verify the battery is installed and energized. The device shall have program backup capabilities that prevent the loss of schedules for at least 7 days, and the time and date settings for at least 72 hours if power is interrupted.
- Override time limit is no more than 2 hours. When the lights are switched off, each lighting circuit can be turned back on manually. Most systems will either send out another OFF signal through the entire lighting network to command all lights back off, or consist of an override timer that will expire and turn off the lights that were manually turned on. Regardless of the control strategy, lights that were manually turned ON during an OFF period should only be operating for up to 2 hours before they are automatically turned off again.
- Verify that override switch is readily accessible and located so that a person using the device can see the lights being controlled—for example, individual override switch per enclosed office or centrally located switch when serving an open office space.
- Verify that model numbers of all automatic time switch controls are listed on the Energy Commission database as “Certified Appliances & Control Devices.” <http://www.energy.ca.gov/appliances/database/>

Functional Testing**Step 1: Simulate occupied condition.**

Set ON time schedule to include actual time or adjust time to be within the ON time schedule (whichever is easier).

Verify and Document

- All lights can be enabled. Some systems may turn the lights on automatically at the scheduled time, but others may require that lights be turned on manually using their respective area control switch.
- Verify the local lighting circuit switch only operates lights in the area in which the switch is located. This is particularly important in enclosed spaces to ensure only lights within the enclosed space are controlled. However, switches serving open spaces should also control only lights in the designated zone.

Step 2: Simulate unoccupied condition.

Set the OFF time schedule to include the actual time, or adjust the time to be within the OFF time schedule (whichever is easier).

Verify and Document

- All non-exempt lights turn off. Most systems warn occupants that the lights are about to turn off by sending a pulse through the lighting circuits to “flicker” the lights or provide another form of visual or audible annunciation.
- Manual override switch is functional. Enabling the manual override switch allows only the lights in the selected space where the switch is located to turn ON. This is particularly important in enclosed spaces to ensure only lights within the enclosed space are controlled, however, switches serving open spaces should also control only lights in the designated zone. The lights should remain ON throughout the override time period (refer to §131(d)2D for maximum override times) and the system indicates that the lights are about to be turned off again.
- All non-exempt lights turn off when the next OFF signal is supplied to the lighting control circuits or the override time has expired. In order to reduce testing time associated with the complete OFF-Manual override-OFF sequence, it is recommended that the override time be shortened so that the entire sequence can be witnessed within a reasonable amount of time.
- The device has program backup capabilities that prevent the loss of schedules for at least 7 days, and the loss of time and date setting for at least 72 hours if power is interrupted.

Step 3: Return system back to normal operating condition.

Ensure all schedules, setpoints, operating conditions, and control parameters are placed back at their initial conditions. Ensure the override time period is no more than 2 hours.

It is also good practice to leave a schedule in the timeclock itself for easy reference and to leave a blank schedule form so that the users can document any schedule changes. See the example below.

10.8.8 (NA7.7) Outdoor Lighting Shut-off Controls

At-A-Glance**NA7.7 Outdoor Lighting Shut-off Controls****Use Form OLTG-2A****Purpose of the Test**

The purpose of these test is to ensure that all outdoor lighting regulated by §132(c)1 are automatically turned off during daytime and that lights subject to §132(c)2 are additionally controlled by a bi-level time switch control, or a motion sensor. For all outdoor lighting regulated by §132(c)2 (lighting of building facades, parking lots, sales and non-sales canopies, all outdoor sales areas, and student pick-up/drop off zones) the time switch controls are configured to do both of the following: 1) scheduling controls to automatically turn off all the lighting, and 2) scheduling controls to automatically reduce applicable lighting power by 50 to 80 percent. A motion sensor is an acceptable alternative to the bi-level time sweep controls.

Benefits of the Tests

Automated controls to turn off outdoor lighting during daytime hours, and when not needed during nighttime hours, prevent energy waste.

Instrumentation

This test verifies the functionality of installed automatic controls visually and does not require special instrumentation.

Test Conditions

All outdoor luminaires must be wired and powered.

Lighting control system must be installed and ready for system operation, including completion of all start-up procedures, per manufacturer's recommendations.

Estimated Time to Complete

Construction Inspection: 0.5 to 2 hours (depending on familiarity with lighting control programming language)

Equipment Test: 0.5 to 2 hours (depending on familiarity with lighting control programming language, number of lighting circuits to be tested)

Acceptance Criteria

Astronomical time switch controls are programmed to turn off lights when daylight is available.

Automatic time switch controls are capable of (1) turning off the lighting when not needed in accordance with §132(c)2 and (2) reducing the lighting power (in watts) by at least 50 percent but not exceeding 80 percent.

The correct date and time are properly set in the lighting controllers.

All lights turn OFF at the preprogrammed, scheduled times.

Photocontrols automatically turn off the outdoor lighting when daylight is available.

Ensure that astronomical time switch controls and automatic time switch controls have been certified to the Energy Commission in accordance with the applicable provision in §119.

Verify that model numbers of all such controls are listed on the Energy Commission database

NA7.7.1 – Outdoor Motion Sensor Acceptance

Note: The motion sensor must be installed in conjunction with a photocontrol or astronomical time switch that automatically turns off the outdoor lighting when daylight is available.

Construction Inspection

Ensure that:

- Motion sensor has been located to minimize false signals
- Sensor is not triggered by motion outside of adjacent area. Desired motion sensor coverage is not blocked by obstruction that could adversely affect performance

Functional testing

Test conditions: Simulate or provide conditions so that outdoor photocontrol or astronomical time switch is in night time mode and is otherwise turning lights ON.

1. Simulate motion in area under lights controlled by the motion sensor. Verify and document the following:
 - a. Status indicator operates correctly.
 - b. Lights controlled by motion sensors turn on immediately upon entry into the area lit by the controlled lights near the motion sensor
 - c. Signal sensitivity is adequate to achieve desired control
2. Simulate no motion in area with lighting controlled by the sensor but with motion adjacent to this area. Verify and document the following:
 - a. Lights controlled by motion sensors turn off within a maximum of 30 minutes from the start of an unoccupied condition per §119(d).
 - b. The occupant sensor does not trigger a false “on” from movement outside of the controlled area
 - c. Signal sensitivity is adequate to achieve desired control.

NA7.7.2 – Outdoor Lighting Shut-off Controls

Construction Inspection

1. Outdoor Lighting Shut-off Controls Construction Inspection

- a. Astronomical time switch controls and automatic time switch controls have been certified to the Energy Commission in accordance with the applicable provision in §119. Verify that model numbers of all such controls are listed on the Energy Commission database as “Certified Appliances & Control Devices.”
 - b. Controls to turn off lights during daytime hours are installed
 - c. Astronomical and standard time switch control is programmed with acceptable weekday, weekend, and holiday (if applicable) schedules
 - d. Demonstrate and document for the owner time switch programming including weekday, weekend, holiday schedules as well as all set-up and preference program settings
2. Lighting systems that meet the criteria of §132(c)2 shall have a scheduling control (time switch) installed which is able to schedule separately:
 - a. A reduction in outdoor lighting power by 50 to 80 percent
 - b. Turning off all outdoor lighting covered by §132(c)2
 - c. Verify that the correct time and date is properly set in the standard and astronomical time switch.
 - d. Verify that the correct latitude, longitude and time zone are set in the astronomical time switch.
 - e. Verify the battery back-up (if applicable) is installed and energized in the standard and astronomical time switch.

NA7.7.2.2 – Outdoor Photocontrol Functional testing

Note: Photocontrol must be used in conjunction with time switch or motion sensor to meet the requirements of §132(c)2

1. Nighttime test: Simulate or provide conditions without daylight. Verify and document:
 - a. Controlled lights turn on
2. Sunrise test: Provide between 10 and 30 horizontal footcandles (fc) to photosensor. Verify and document the following
 - a. Controlled lights turn off

NA7.7.2.3 – Astronomical Time Switch Functional testing

1. Power off test: Program control with location information, local date and time, and schedules. Disconnect control from power source for at least 1 hour. Verify and document:
 - a. Control retains all programmed settings and local date and time

-
2. Night schedule ON test: Simulate or provide times when the sun has set and lights are scheduled to be ON. Verify and document:
 - a. Controlled lights turn on
 3. Night schedule OFF test: Simulate or provide times when the sun has set and lights are scheduled to be OFF. Verify and document:
 - a. Controlled lights turn off
 4. Sunrise test: Simulate or provide the programmed offset time after the time of local sunrise
 - a. Controlled lights turn off

NA7.7.2.4 – Standard (non-astronomical) Time Switch Functional Testing

Note: this control must be used in conjunction with a photocontrol to meet requirements of §132(c).

1. Power off test: Program control with local date and time and schedules. Disconnect control from power source for at least 1 hour. Verify and document:
 - a. Control retains all programmed schedules and local date and time
2. On schedule test: Simulate or provide times when lights are scheduled to be ON. Verify and document:
 - a. Controlled lights turn on
3. Schedule test: Simulate or provide times when the sun has set and lights are scheduled to be OFF. Verify and document:
 - a. Controlled lights turn off

10.9 Envelope & Mechanical Acceptance Forms

There are two new envelope forms, fifteen mechanical forms used to document the completion of these procedures. Each form includes a series of check boxes relating to each test or verification that needs to be performed. When completing the forms, check the appropriate box on the form after each test or verification is completed. Where the form includes data entry locations other than check boxes, enter the data requested on the form. These forms are located in Appendix A:

Envelope

- ENV-2A - Fenestration Acceptance

Mechanical

- MECH-2A - Ventilation Systems - Variable and Constant Volume Systems
- MECH-3A - Constant-Volume, Single-Zone, Unitary A/C and Heat Pumps
- MECH-4A - Air Distribution Systems

- MECH-5A - Air Economizer Controls
MECH-6A - Demand Control Ventilation (DVC)
- MECH-7A - Supply Fan Variable Flow Controls (VFC)
- MECH-8A - Valve Leakage Test
- MECH-9A - Supply Water Temperature Reset
- MECH-10A - Hydronic System Variable Flow Control
- MECH-11A - Automatic Demand Shed Control Acceptance
- MECH-12A - Fault Detection & Diagnostics for DX Units
- MECH-13A - Automatic Fault Detection & Diagnostics for Air Handling & Zone Terminal Units
- MECH-14A - Distributed Energy Storage DX AC Systems Test
- MECH-15A - Thermal Energy Storage (TES) Systems

Envelope

ENV-2A – Fenestration Acceptance Certificate

The form is separated into two basic sections: project information; general information; and declaration statement of acceptance. Each section consists of a combination of data entry requirements and check boxes.

Project Information

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.
- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.
- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.

General Information

This section consists of a combination of data entry requirements and check boxes, all of which are self-explanatory. Complete check boxes and enter data as instructed.

Statement of Acceptance

This section consists of a combination of check boxes and data entry requirements, including signature; date; and license number. Complete check boxes and enter data as instructed.

ENV-2A – Certificate of Acceptance Page 2 of 2

The form is used to document the overall final results of all acceptance tests. The Responsibility Party shall verify the thermal performance (U-factor and SHGC) of each specified fenestration product being installed. The Responsible Party

ensures that each product matches the fenestration certificate, energy compliance documentation and building plans.

Summary of Acceptance Tests

- FENESTRATION PRODUCT MODELS are listed for each column representing one product. Additional sheets may be required to document each product line beyond four.
- MANUFACTURED PRODUCT CODE – should match either the NFRC or Energy Commission Label Certificate.
- NFRC CERTIFIED PRODUCT DIRECTORY, CPD, Indicate the CPD number to include dashes between the numbers. The enforcement agency can verify each product matches the installed fenestration as indicated the energy compliance documentation, building plans and receipt or Purchase Order at http://cpd.nfrc.org/search/search_cpdnum.aspx
- FRAME and SASH TYPE – Indicate type if applicable, if installed it should match the energy compliance documentation, building plans and receipt or Purchase Order.
- GLAZING LAYERS – Check applicable box and should match the energy compliance documentation, building plans and receipt or Purchase Order.
- PROOF – Check box only after verification of each product line is complete. If products do not match, the enforcement agency may have the option to stop installation and re-comply with energy compliance for installing less thermal performance as indicated in the energy compliance documentation, building plans and receipt or Purchase Order.
- ENFORCEMENT AGENCY VERIFICATION The enforcement agency has the option to verify each product if the agency suspects the listed CPD number does not match the original documentation.
http://cpd.nfrc.org/search/search_cpdnum.aspx

Mechanical

MECH-2 – Certificate of Out Door Acceptance - Page 1 of 2

Ventilation Systems –Variable Air and Constant Volume System Acceptance Document

This form is used to document results of the minimum outdoor air ventilation tests for both constant and variable air volume fan systems. A separate form should be completed for each system tested. The form is separated into six basic sections: project information; pre-test inspection; functional testing; testing calculations and results; pass/fail evaluation; and certification statement. Each section consists of a combination of data entry requirements and check boxes.

Project Information

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.

- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.
- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.
- TELEPHONE is the phone number where the testing authority can be reached during regular business hours.
- VENTILATION SYSTEM NAME/DESIGNATION is the name or unique identifier for the system being tested. For example: AHU-1; AC-3; etc.

Declaration Statement of Acceptance

This section consists of a combination of check boxes and data entry requirements, including signature; date; and license number. Complete check boxes and enter data as instructed.

General Information

This section consists of a combination of data entry requirements and check boxes, all of which are self-explanatory. Complete check boxes and enter data as instructed.

MECH-2A – Certificate of Acceptance Page 2 of 2

The form is used to document the overall final results of all acceptance tests.

Summary of Acceptance Tests

- SYSTEM ACCEPTANCE DOCUMENT refers to the name of the test form that has been completed. For example: "Ventilation System Acceptance document (AHU-1). This designates the acceptance test of outdoor air ventilation for air handling unit #1. Typically an individual form is completed for each piece of equipment tested.
- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.
- DATE OF TEST is the date each test was actually performed.
- PASS/FAIL is the final outcome of the acceptance test.

Pre-test Inspection

This section consists of check boxes for both constant and variable air volume systems. Complete only the check boxes associated with the appropriate system type.

Functional Testing

This section consists of data entry requirements for both constant and variable air volume systems. Enter data associated with the appropriate system type as instructed.

Testing Calculations and Results

This section consists of data entry requirements for both constant and variable air volume systems. Enter data associated with the appropriate system type as instructed.

Pass/Fail Evaluation

Check the appropriate box. Any portion that fails should be explained in the given rows.

MECH-3A – Constant volume, Single-Zone, Unitary Air Conditioning and Heat Pumps Acceptance Document

This form is used to document results of packaged HVAC system operating tests. A separate form should be completed for each system tested. The form is separated into seven basic sections: project information; pre-test inspection; operating modes; functional testing requirements; testing results; pass/fail evaluation; and certification statement. Each section consists of a combination of data entry requirements and check boxes.

Project Information

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.
- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.
- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.
- TELEPHONE is the phone number where the testing authority can be reached during regular business hours.
- PACKAGED HVAC NAME/DESIGNATION is the name or unique identifier for the system being tested. For example: ACU-1; DX-3; etc.

Pre-test Inspection

This section consists of check boxes. Complete check boxes as instructed.

Operating Modes

This section documents the various operating modes for packaged HVAC systems under which they will be tested. Note that operating modes “F” and “G” are associated with systems that do not have an economizer and operating modes.

Functional Testing

This section consists of check boxes arranged in a matrix pattern, with the various operating modes listed horizontally and expected system responses listed vertically. As the HVAC system is tested under each applicable operating mode, check the box associated with the expected system response. Again, note that operating modes “F” and “G” are mutually exclusive with operating modes “H” and “I”. If the unit does not have an economizer, only modes “F” and “G” should be checked. Conversely, “H” and “I” are used only for systems with an economizer.

Testing Results

This section consists of data entry requirements for all operating modes. Enter data associated with the appropriate operating mode as instructed.

Pass/Fail Evaluation

Check the appropriate box as instructed.

Certification Statement

The statement of compliance is signed by the person responsible for performing the test and verifying system performance. The signatory provides the following: name; company name; signature and date signed; as well as license number and expiration date.

MECH-4A – Air Distribution Systems Acceptance Document

This form is used to document results of both stand-alone and DDC controlled economizer operating tests. A separate form should be completed for each system tested. The form is separated into six basic sections: project information; pre-test inspection; functional testing requirements; testing results; pass/fail evaluation; and certification statement. Each section consists of a combination of data entry requirements and check boxes.

Project Information

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.
- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.
- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.
- TELEPHONE is the phone number where the testing authority can be reached during regular business hours.
- AIR ECONOMIZER NAME/DESIGNATION is the name or unique identifier for the economizer being tested (typically associated with a particular HVAC system). For example: AC-1; AHU-3; etc.

Pre-test Inspection

This section consists of check boxes for both stand-alone and DDC controlled economizers. Complete the appropriate check boxes as instructed.

Functional Testing

This section consists of check boxes for each test procedure. Complete check boxes as instructed.

Testing Results

This section consists of data entry requirements for all tests. Enter data as instructed.

Pass/Fail Evaluation

Check the appropriate box as instructed.

Certification Statement

The statement of compliance is signed by the person responsible for performing the test and verifying system performance. The signatory provides the following: name; company name; signature and date signed; as well as license number and expiration date.

MECH-5A – Air Economizer Acceptance Document

This form is used to document results of duct leakage tests performed on specific packaged HVAC systems. A separate form should be completed for each system tested. The form is separated into five basic sections: project information; pre-test inspection; functional testing requirements; pass/fail evaluation; and certification statement. Each section consists of a combination of data entry requirements and check boxes.

Project Information

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.
- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.
- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.
- TELEPHONE is the phone number where the testing authority can be reached during regular business hours.
- AIR DISTRIBUTOR NAME/DESIGNATION is the name or unique identifier for the ductwork being tested (typically associated with a particular HVAC system). For example: ACU-1 ductwork; etc.

Construction Inspection

This section consists of check boxes. Complete check boxes as instructed.

Certification Statement

The statement of compliance is signed by the person responsible for performing the test and verifying system performance. The signatory provides the following: name; company name; signature and date signed; as well as license number and expiration date.

This form is used to verify duct tightness by the installer and/or HERS rater (third-party). Compliance credit requires third-party field verification.

Installer Certification

New Construction

- ENTER TEST LEAKAGE– enter the actual measured duct leakage value.

- **FAN FLOW**
 - **CALCULATED FAN FLOW** – enter the calculated fan flow either by multiplying 400cfm/ton times the number of tons of cooling or by entering 21.7 times the heating capacity of the unit being stalled in kBtu/h. In case of more than one separate fan flow unit calculate the fan flow for each separately and enter the value in the Measured Values column.
 - **MEASURED FAN FLOW** – enter the actual fan flow measured value in the Measured Values column.
 - **LEAKAGE PERCENTAGE** – enter the leakage fraction by dividing the Test Leakage by either the calculated or measured fan flow. Enter the value in the Measured Values column.
- **PASS OR FAIL** – check the “Pass” box if duct leakage is less than 6 percent.

Alterations

- **ENTER PRE-TEST LEAKAGE FLOW** – enter the actual measured duct leakage value for existing ductwork where the single-zone unit is being replaced or having a major component replaced (§149(b)1E) including:
 - Cooling coil
 - Furnace
 - Condenser coil (split system) or
 - Condensing unit (split system)Different levels of leakage requirements apply to new and existing ductwork (see §149(b)D).
- **ENTER FINAL TEST FOR LEAKAGE** – enter the actual measured duct leakage value after alterations are complete. There are three options for meeting the leakage requirements.
- The measured duct leakage shall be less than 15 percent of fan flow; or
 - The duct leakage shall be reduced by more than 60 percent relative to the leakage prior to the equipment having been replaced and a visual inspection shall demonstrate that all accessible leaks have been sealed; or
 - If it is not possible to meet the duct sealing requirements of Subsections a. or b., all accessible leaks shall be sealed and verified through a visual inspection by a certified HERS rater.

Exception to §149(b)1Dii: Existing duct systems that are extended, which are constructed, insulated or sealed with asbestos.

Otherwise check the “Fail” box. See §149(b)1D for additional applicable information.

-
- ENTER REDUCTION IN LEAKAGE – This is option b. from above. If the leakage after the alteration is reduced by 60 percent then the system passes.
 - NEW DUCTS – If all the ducts are new the leakage must not be over 6 percent. Enter these values here.
 - TEST OR VERIFICATION STANDARDS
 - Leakage Percentage must be less than 15 percent. After the alteration the duct leakage must be less than 15 percent of fan flow.
 - Leakage Reduction - If a Pre-Test was conducted on the system before any alterations the final test after the alteration must less than 60 percent.
 - If none of the above options a HERS rater can test the duct system to verify by smoke test that all accessible leaks have been sealed.
 - SIGNATURE AND DATE – enter the signature of the installer and date of the test.
 - NAME OF INSTALLING CONTRACTOR OR SUBCONTRACTOR – enter the name of the company of the contractor of subcontractor.

HERS Rater Compliance Statement

The HERS rater fills out the following information:

- HERS RATER INFORMATION
 - HERS Rater – Rater prints name and telephone number.
 - Certifying Signature – After tests passes the HERS Rater signs and dates form.
 - FIRM – Enter company name
 - SAMPLE GROUP NUMBER – Enter sample number here.
Example, System 3 out of 7.
- ENTER TEST LEAKAGE– enter the actual measured duct leakage value.
- FAN FLOW
 - CALCULATED FAN FLOW – enter the calculated fan flow either by multiplying 400 cfm/ton times the number of tons of cooling or by entering 21.7 times the heating capacity of the unit being stalled in kBtu/h. In case of more than one separate fan flow unit calculate the fan flow for each separately and enter the value in the Measured Values column.
 - LEAKAGE PERCENTAGE – enter the leakage fraction by dividing the Test Leakage by either the calculated or measured fan flow.
Enter the value in the Measured Values column.
- PASS OR FAIL – check the “Pass” box if duct leakage is less than 6 percent.

Alterations

- ENTER PRE-TEST LEAKAGE FLOW – enter the actual measured duct leakage value for existing ductwork where the single-zone unit is being replaced or having a major component replaced (§149(b)E) including:
 - Cooling coil
 - Furnace
 - Condenser coil (split system) or
 - Condensing unit (split system)Different levels of leakage requirements apply to new and existing ductwork (see §149(b)D).
- ENTER FINAL TEST FOR LEAKAGE – enter the actual measured duct leakage value after alterations are complete. There are three options for meeting the leakage requirements.
 - The measured duct leakage shall be less than 15 percent of fan flow; or
 - The duct leakage shall be reduced by more than 60 percent relative to the leakage prior to the equipment having been replaced and a visual inspection shall demonstrate that all accessible leaks have been sealed; or
 - If it is not possible to meet the duct sealing requirements of Subsections a. or b., all accessible leaks shall be sealed and verified through a visual inspection by a certified HERS rater.

Exception to §149(b)1Dii: Existing duct systems that are extended, which are constructed, insulated or sealed with asbestos.

Otherwise check the “Fail” box. See §149(b)1D for additional applicable information.

- ENTER REDUCTION IN LEAKAGE – This is option b. from above. If the leakage after the alteration is reduced by 60 percent then the system passes.
- NEW DUCTS – If all the ducts are new the leakage must not be over 6%. Enter this value here.
- TEST OR VERIFICATION STANDARDS
 - Leakage Percentage must be less than 15 percent. After the alteration the duct leakage must be less than 15 percent of fan flow.
 - Leakage Reduction - If a Pre-Test was conducted on the system before any alterations the final test after the alteration must less than 60 percent.
 - If none of the above options a HERS rater can test the duct system to verify by smoke test that all accessible leaks have been sealed.

MECH-6-A – Demand Controlled Ventilation Systems Acceptance Document

This form is used to document results of operational tests for HVAC systems required to utilize demand ventilation control. A separate form should be completed for each system tested. The form is separated into six basic sections: project information; pre-test inspection; functional testing requirements; testing results; pass/fail evaluation; and certification statement. Each section consists of a combination of data entry requirements and check boxes.

Project Information

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.
- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.
- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.
- TELEPHONE is the phone number where the testing authority can be reached during regular business hours.
- DEMAND CONTROLLED VENTILATION NAME/DESIGNATION is the name or unique identifier for the HVAC unit utilizing ventilation control that is being tested. For example: AC-1; AHU-3; etc.

Pre-test Inspection

This section consists of check boxes. Complete check boxes as instructed.

Functional Testing

This section consists of both check boxes and data entry for each test procedure. Complete all check boxes and enter data as instructed.

Testing Results

This section consists of data entry requirements for all tests. Enter data as instructed.

Pass/Fail Evaluation

Check the appropriate box as instructed.

Certification Statement

The statement of compliance is signed by the person responsible for performing the test and verifying system performance. The signatory provides the following: name; company name; signature and date signed; as well as license number and expiration date.

MECH-7A - Supply Fan Variable Flow Control Acceptance Document

This form is used to document results of operational tests for HVAC supply fans required to utilize variable flow control. A separate form should be completed for each system tested. The form is separated into seven basic sections: project

information; pre-test inspection; functional testing requirements; test calculations; testing results; pass/fail evaluation; and certification statement. Each section consists of a combination of data entry requirements and check boxes.

Project Information

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.
- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.
- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.
- TELEPHONE is the phone number where the testing authority can be reached during regular business hours.
- VARIABLE FREQUENCY DRIVE NAME/DESIGNATION is the name or unique identifier for the supply fan that is being tested (typically associated with a particular HVAC system). For example: SF-1 in ACU-1; SF-2 in AHU-3 (multiple fan unit); etc.

Pre-test Inspection

This section consists of check boxes. Complete check boxes as instructed.

Functional Testing

This section consists of data entry requirements for each test procedure. Enter data as instructed.

Test Calculations

This section consists of data entry requirements for all tests. Enter data as instructed.

Testing Results

This section consists of data entry requirements for all tests. Enter data as instructed.

Pass/Fail Evaluation

Check the appropriate box as instructed.

Certification Statement

The statement of compliance is signed by the person responsible for performing the test and verifying system performance. The signatory provides the following: name; company name; signature and date signed; as well as license number and expiration date.

MECH-8A – Valve Leakage Test Acceptance Document

This form is used to document the results for various hydronic system operating tests. The form was designed so that data from up to five hydronic systems (for example: chilled water; heating hot water; water-loop heat pump; etc.) could be

recorded on one form. The form is separated into seven basic sections: project information; pre-test inspection; system type; select acceptance tests; functional testing requirements; pass/fail evaluation; and certification statement. Each section consists of a combination of data entry requirements and check boxes.

Project Information

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.
- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.
- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.
- TELEPHONE is the phone number where the testing authority can be reached during regular business hours.
- HYDRONIC SYSTEM NAME/DESIGNATION is the name or unique identifier for the system(s) being tested. For example: Chilled water; heating hot water; water-loop heat pump; etc.

Pre-test Inspection

This section consists of check boxes. Complete check boxes as instructed.

System Type

This section documents the various system that will be tested. There are five columns under the "System ID" heading labeled 1 through 5 and are identified as follows: column 1 – chilled water systems; column 2 – heating hot water systems; column 3 – water-loop heat pumps; and column 4 and column 5 – other system types. Check each system type that is tested in the appropriate column.

Select Acceptance Test

This section documents which of the various acceptance tests will be performed for each system type. Check the appropriate column for each test that applies to the respective system type.

Functional Testing

This section consists of check boxes and data entry requirements arranged by individual test. Check each box or enter data in each System ID column for which the specific test applies.

Pass/Fail Evaluation

Check the appropriate box as instructed.

Certification Statement

The statement of compliance is signed by the person responsible for performing the test and verifying system performance. The signatory provides the following: name; company name; signature and date signed; as well as license number and expiration date.

MECH-9A – Supply Water Temperature Reset

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.
- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.
- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.

MECH-10A – Hydronic System Variable Flow Control

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.
- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.
- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.

Pre-test Inspection

This section consists of check boxes. Complete check boxes as instructed.

System Type

This section documents the various system that will be tested. There are five columns under the “System ID” heading labeled 1 through 5 and are identified as follows: column 1 – chilled water systems; column 2 – heating hot water systems; column 3 – water-loop heat pumps; and column 4 and column 5 – other system types. Check each system type that is tested in the appropriate column.

Select Acceptance Test

This section documents which of the various acceptance tests will be performed for each system type. Check the appropriate column for each test that applies to the respective system type.

Functional Testing

This section consists of check boxes and data entry requirements arranged by individual test. Check each box or enter data in each System ID column for which the specific test applies.

Pass/Fail Evaluation

Check the appropriate box as instructed.

Certification Statement

The statement of compliance is signed by the person responsible for performing the test and verifying system performance. The signatory provides the following: name; company name; signature and date signed; as well as license number and expiration date.

MECH-11A – Automatic Demand Shed Control Acceptance

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.
- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.
- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.

Pre-test Inspection

This section consists of check boxes. Complete check boxes as instructed.

System Type

This section documents the various system that will be tested. There are five columns under the “System ID” heading labeled 1 through 5 and are identified as follows: column 1 – chilled water systems; column 2 – heating hot water systems; column 3 – water-loop heat pumps; and column 4 and column 5 – other system types. Check each system type that is tested in the appropriate column.

Select Acceptance Test

This section documents which of the various acceptance tests will be performed for each system type. Check the appropriate column for each test that applies to the respective system type.

Functional Testing

This section consists of check boxes and data entry requirements arranged by individual test. Check each box or enter data in each System ID column for which the specific test applies.

Pass/Fail Evaluation

Check the appropriate box as instructed.

Certification Statement

The statement of compliance is signed by the person responsible for performing the test and verifying system performance. The signatory provides the following: name; company name; signature and date signed; as well as license number and expiration date.

MECH-12A – Fault Detection & Diagnostics for DX Units

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.
- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.
- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.

Pre-test Inspection

This section consists of check boxes. Complete check boxes as instructed.

System Type

This section documents the various system that will be tested. There are five columns under the “System ID” heading labeled 1 through 5 and are identified as follows: column 1 – chilled water systems; column 2 – heating hot water systems; column 3 – water-loop heat pumps; and column 4 and column 5 – other system types. Check each system type that is tested in the appropriate column.

Select Acceptance Test

This section documents which of the various acceptance tests will be performed for each system type. Check the appropriate column for each test that applies to the respective system type.

Functional Testing

This section consists of check boxes and data entry requirements arranged by individual test. Check each box or enter data in each System ID column for which the specific test applies.

Pass/Fail Evaluation

Check the appropriate box as instructed.

Certification Statement

The statement of compliance is signed by the person responsible for performing the test and verifying system performance. The signatory provides the following: name; company name; signature and date signed; as well as license number and expiration date.

MECH-13A – Automatic Fault Detection & Diagnostics for Air Handling & Zone Terminal Units

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.
- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.

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- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.

Pre-test Inspection

This section consists of check boxes. Complete check boxes as instructed.

System Type

This section documents the various system that will be tested. There are five columns under the "System ID" heading labeled 1 through 5 and are identified as follows: column 1 – chilled water systems; column 2 – heating hot water systems; column 3 – water-loop heat pumps; and column 4 and column 5 – other system types. Check each system type that is tested in the appropriate column.

Select Acceptance Test

This section documents which of the various acceptance tests will be performed for each system type. Check the appropriate column for each test that applies to the respective system type.

Functional Testing

This section consists of check boxes and data entry requirements arranged by individual test. Check each box or enter data in each System ID column for which the specific test applies.

Pass/Fail Evaluation

Check the appropriate box as instructed.

Certification Statement

The statement of compliance is signed by the person responsible for performing the test and verifying system performance. The signatory provides the following: name; company name; signature and date signed; as well as license number and expiration date.

MECH-14A – Distributed Energy Storage DX AC Systems Test

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.
- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.
- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.

Pre-test Inspection

This section consists of check boxes. Complete check boxes as instructed.

System Type

This section documents the various system that will be tested. There are five columns under the “System ID” heading labeled 1 through 5 and are identified as follows: column 1 – chilled water systems; column 2 – heating hot water systems; column 3 – water-loop heat pumps; and column 4 and column 5 – other system types. Check each system type that is tested in the appropriate column.

Select Acceptance Test

This section documents which of the various acceptance tests will be performed for each system type. Check the appropriate column for each test that applies to the respective system type.

Functional Testing

This section consists of check boxes and data entry requirements arranged by individual test. Check each box or enter data in each System ID column for which the specific test applies.

Pass/Fail Evaluation

Check the appropriate box as instructed.

Certification Statement

The statement of compliance is signed by the person responsible for performing the test and verifying system performance. The signatory provides the following: name; company name; signature and date signed; as well as license number and expiration date.

MECH-15A – Thermal Energy Storage (TES) Systems

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.
- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.
- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.

Pre-test Inspection

This section consists of check boxes. Complete check boxes as instructed.

System Type

This section documents the various system that will be tested. There are five columns under the “System ID” heading labeled 1 through 5 and are identified as follows: column 1 – chilled water systems; column 2 – heating hot water systems; column 3 – water-loop heat pumps; and column 4 and column 5 – other system types. Check each system type that is tested in the appropriate column.

Select Acceptance Test

This section documents which of the various acceptance tests will be performed for each system type. Check the appropriate column for each test that applies to the respective system type.

Functional Testing

This section consists of check boxes and data entry requirements arranged by individual test. Check each box or enter data in each System ID column for which the specific test applies.

Pass/Fail Evaluation

Check the appropriate box as instructed.

Certification Statement

The statement of compliance is signed by the person responsible for performing the test and verifying system performance. The signatory provides the following: name; company name; signature and date signed; as well as license number and expiration date.

10.10 Lighting Forms for Acceptance Requirements

There are three forms used to document the completion of these procedures. Each form includes a series of check boxes relating to each test or verification that needs to be performed. When completing the forms, check the appropriate box on the form after each test or verification is completed. Where the form includes data entry locations other than check boxes, enter the data requested on the form.

These forms are located in Appendix A.

- Lighting Control Acceptance Document
- Automatic Daylighting Controls Acceptance Document

LTG-2A – Lighting Control Acceptance Document

This form is used to document the results for various lighting control tests. The form was designed so that data for three lighting control strategies (occupancy sensors, manual daylight control, and automatic time switch) could be recorded on one form. The form is separated into six basic sections: project information; pre-test inspection; select acceptance tests; functional testing requirements; pass/fail evaluation; and certification statement. Each section consists of a combination of data entry requirements and check boxes.

Project Information

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.
- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.

- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.
- TELEPHONE is the phone number where the testing authority can be reached during regular business hours.
- LIGHTING CONTROL SYSTEM NAME/DESIGNATION is the name or unique identifier for the system(s) being tested. For example: “occupancy sensors and lighting sweep.”

Pre-test Inspection

This section consists of check boxes. Complete check boxes as instructed.

Select Acceptance Test

This section documents which of the acceptance tests are to be performed. Check the appropriate box for each applicable test.

Functional Testing

This section consists of data entry requirements arranged by individual test procedures. There are three columns under the “Applicable Lighting Control System” heading labeled 1 through 3 and are identified as follows: column 1 – occupancy sensors; column 2 – manual daylighting controls; and column 3 – automatic time switch controls. Note that the columns are shaded when test procedures do not apply to a particular control strategy. Enter data as instructed in each column.

Pass/Fail Evaluation

Check the appropriate box as instructed.

Certification Statement

The statement of compliance is signed by the person responsible for performing the test and verifying system performance. The signatory provides the following: name; company name; signature and date signed; as well as license number and expiration date.

LTG-3A – Automatic Daylighting Control Acceptance Document

This form is used to document the results for automatic daylighting control tests. The form was designed so that data for three lighting control strategies (continuous dimming, stepped dimming, and stepped switching) could be recorded on one form. The form is separated into six basic sections: project information; pre-test inspection; control systems; functional testing requirements; pass/fail evaluation; and certification statement. Each section consists of a combination of data entry requirements and check boxes.

Project Information

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.

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- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.
 - TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.
 - TELEPHONE is the phone number where the testing authority can be reached during regular business hours.
 - AUTOMATIC DAYLIGHTING CONTROL NAME/DESIGNATION is the name or unique identifier for the system(s) being tested. For example: “continuous dimming – whole building”.

Pre-test Inspection

This section consists of check boxes. Complete check boxes as instructed.

Control Systems

This section documents which control strategy has been tested. Check the appropriate box for each applicable strategy.

Functional Testing

This section consists of data entry requirements arranged by individual test procedures. There are three columns under the “Applicable Control System” heading labeled 1 through 3 and are identified as follows: column 1 – continuous dimming; column 2 – stepped dimming; and column 3 – stepped switching. Note that the columns are shaded when test procedures do not apply to a particular control strategy. Enter data as instructed in each column.

Pass/Fail Evaluation

Check the appropriate box as instructed.

Certification Statement

The statement of compliance is signed by the person responsible for performing the test and verifying system performance. The signatory provides the following: name; company name; signature and date signed; as well as license number and expiration date

10.11 Outdoor Lighting Forms for Acceptance Requirements

There are three forms used to document the completion of these procedures. Each form includes a series of check boxes relating to each test or verification that needs to be performed. When completing the forms, check the appropriate box on the form after each test or verification is completed. Where the form includes data entry locations other than check boxes, enter the data requested on the form.

These forms are located in Appendix A.

- Outdoor Motion Sensor Acceptance
- Outdoor Lighting Shut-off Controls Acceptance Document

OLTG-2A – Outdoor Motion Sensor Acceptance

Project Information

- PROJECT NAME is the title of the project, as shown on the Code Compliance forms.
- DATE is the date of preparation of the compliance submittal package.
- PROJECT ADDRESS is the address of the project as shown on the Code Compliance forms.
- TESTING AUTHORITY is the person responsible for verifying all acceptance tests were performed and each system passed.
- TELEPHONE is the phone number where the testing authority can be reached during regular business hours.
- LIGHTING CONTROL SYSTEM NAME/DESIGNATION is the name or unique identifier for the system(s) being tested. For example: “occupancy sensors and lighting sweep.”